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2017**

 **Teacher
Notes Series**



GREEN HALL
Resource Center

Article # 207

Level

BIOLOGY

Subject Code 5090

Muhammad Shahid

DHA PHASE 4

DHA PHASE 1

GULBERG

JOHAR TOWN

WAPDA TOWN

SADDAR CANTT

3



Biology Notes

Subject Code:5090

2017-18 Edition

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Green Hall Academy



GREEN HALL
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GULBERG JOHAR TOWN WAPDA TOWN SADDAR CANTT DHA Phase-I DHA Phase-IV

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PREFACE

In an effort to provide O-Level students with quality and to the point exam preparatory materials; these notes have been compiled. While writing these notes my special emphasis was on the quality and organization of data. Much of the text has been organized in form of points and bullets. Illustrated diagrams and graphic organizers provide an opportunity to easily imprint data in brain and later on could be recalled.

It is ensured that the text presented; matches with the assessment objectives of CIE. With a check list at the end of every chapter an opportunity is provided to the students so that they can ensure if anything they missed out and at the same time they are preparing according to the learning objectives.

Now when I am talking about the strengths of this material I would like to name all those who make this working a great experience. First of all I am thankful to **Mr. Imran Latif** who provided platform of **Read and Write** so that all the wonderful stuff like this could be published and moreover his encouragement and motivation for working on this resource development really proves his leadership skills. Secondly I am grateful to **Mr. Zafar Sulehri** who always proved to be a source of inspiration through this working and guidance; further his motivational words can't be ignored. Lastly I appreciate the role of **Mr. Zaeshan Nawaz** who always proved himself a helping hand on all technical issues while making a soft copy of this resource.

In the end I hope that these notes will prove themselves a great help for O-Level students and students will enjoy reading these notes as a source of pleasure activity.

Muhammad Shahid

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O-LEVEL

BIOLOGY

**Topic 1: Cell
Structure and
Organization**

NOTES BY

MUHAMMAD SHAHID

Cell: 0334-4463339

Syllabus 2017 – 2019

Content

- 1.1 Plant and animal cells
- 1.2 Specialised cells, tissues and organs

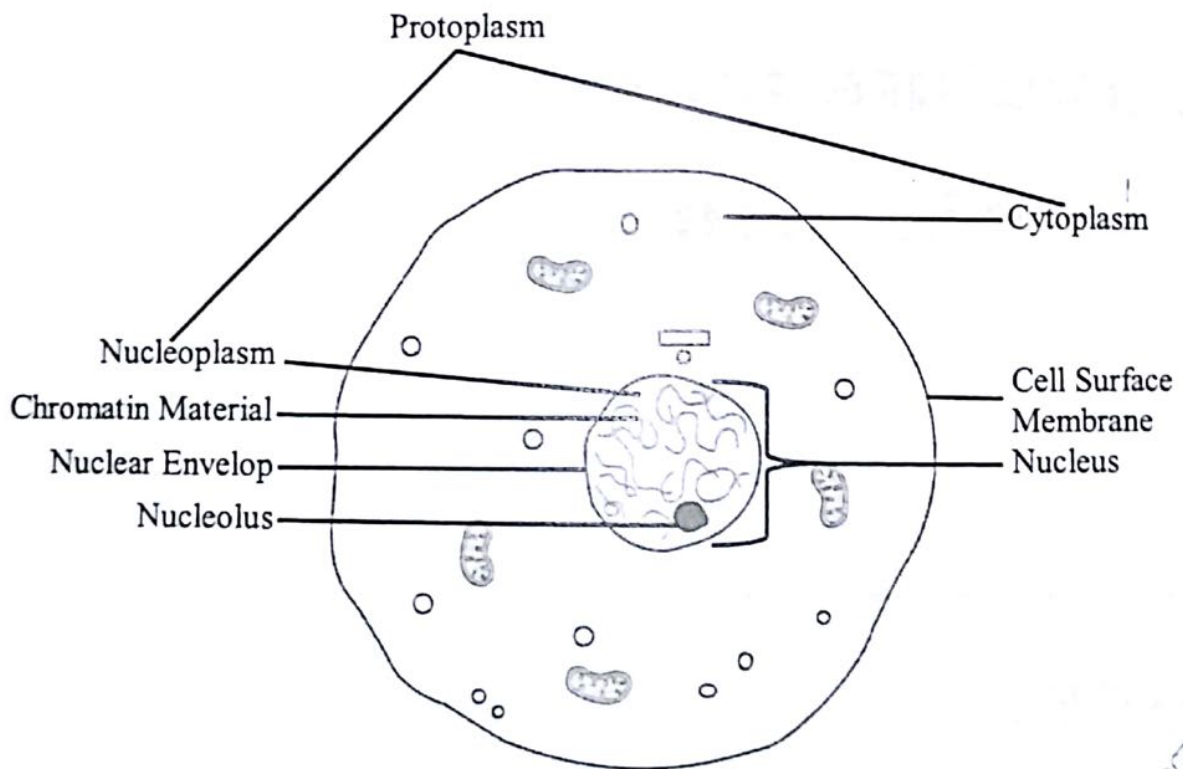
CELL STRUCTURE AND ORGANISATION

The basic unit of life is the **cell**. The simplest living organisms have **one cell** only because of this these organisms are described as **unicellular**. Examples of unicellular organisms includes bacteria (singular bacterium). Most of the other living organisms have many cells, and are described as **multicellular**.

All cells have the following structural features in common:

- **Cell Membrane:** which controls the passage of substances into and out of the cell. One of the most important of those substances is **water**. All other substances passing through the cell membrane are **in solution**.
- **Cytoplasm:** a jelly-like substance in which the chemical reactions of the cell (metabolic reactions) take place.
- **The Nucleus:** This contains a number of **chromosomes** made of the chemical DNA. Chromosomes possess genes which are responsible for programming the cytoplasm to manufacture particular proteins. When a cell divides, it does so by a process called mitosis during which each chromosome forms an exact replica of itself. The two cells formed are identical to each other, and to the original cell.

The cytoplasm and the nucleoplasm make up the protoplasm.

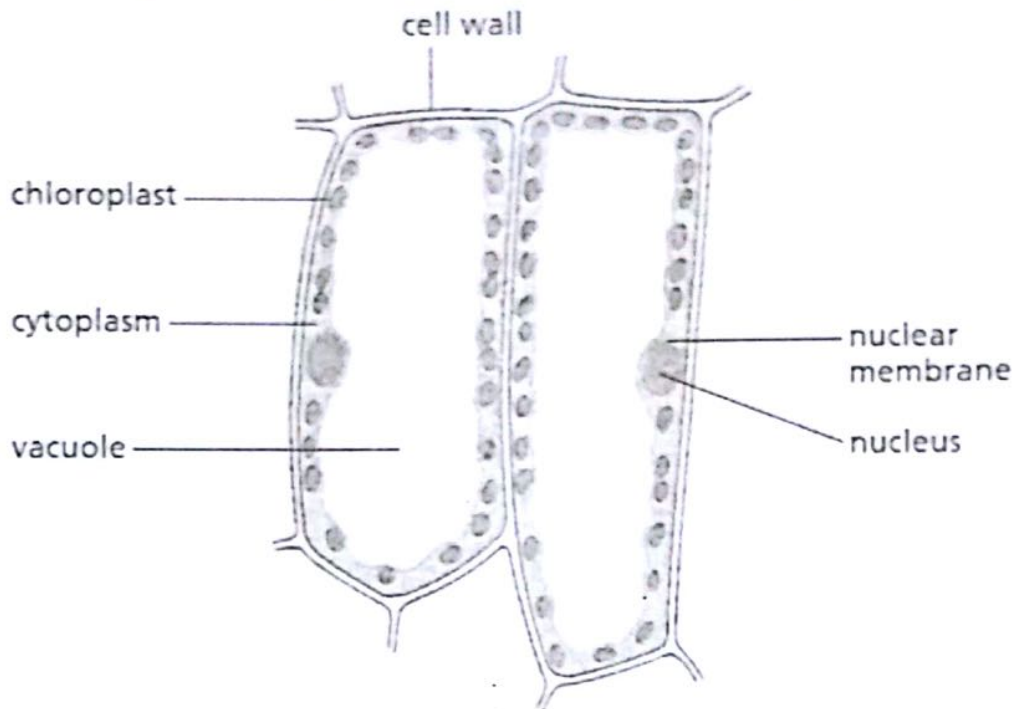


A Generalized Animal Cell

In plant cells there are few additional structures like:

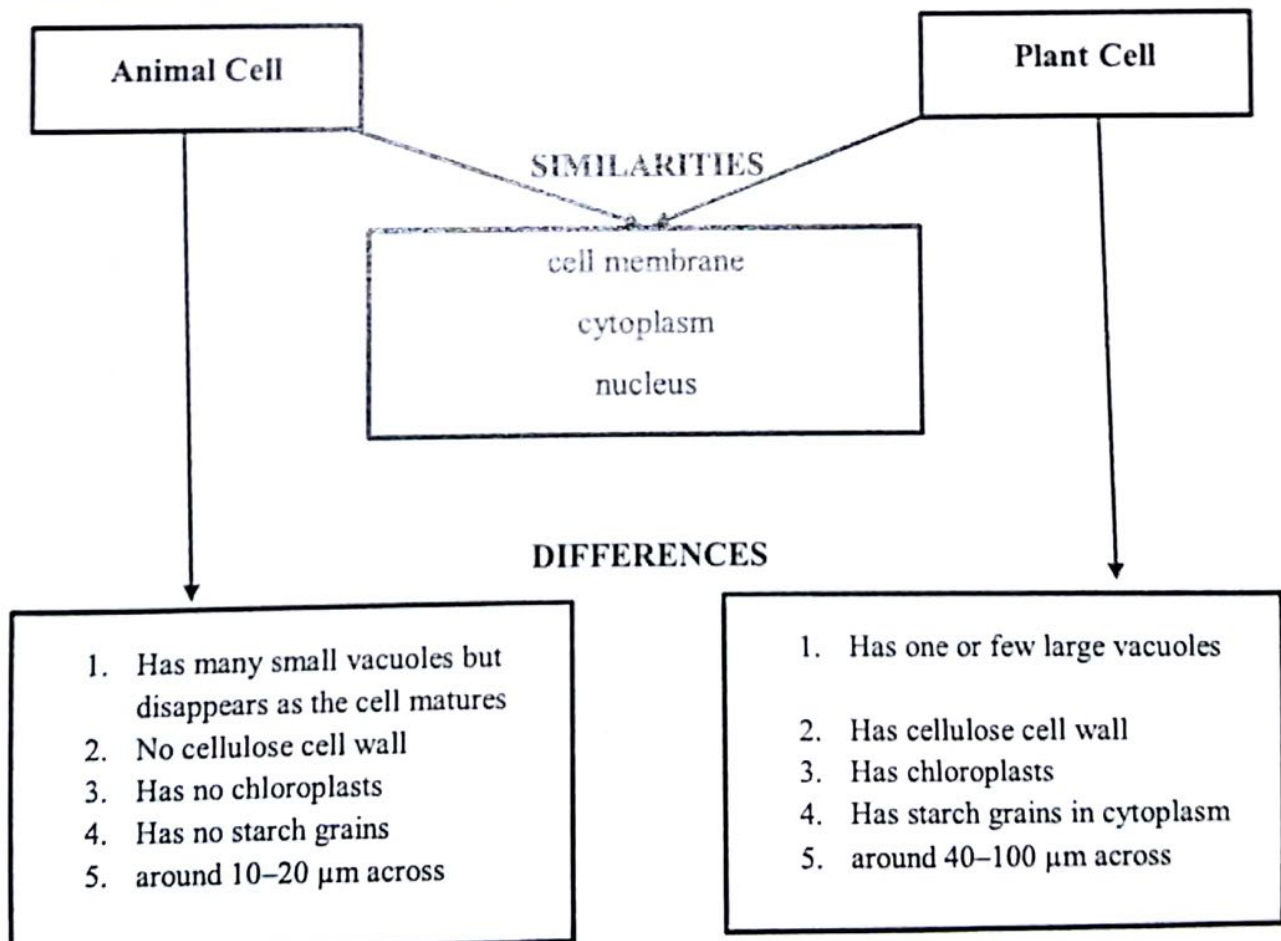
- A **vacuole** (large, central) – a space containing **cell sap**, a solution made up mostly of sugars. The vacuole is sometimes called the 'sap vacuole'. It is separated from the cytoplasm by the vacuolar membrane. Plant cells undergoing cell division do *not* have a vacuole.
- The **Cell Wall** – a 'box' made of cellulose that encloses the cell.

- **The Chloroplast** – small bodies lying in the cytoplasm. They are green in colour as they contain green pigment chlorophyll. They have main role to play in photosynthesis thus chloroplast is present in only those cells which are involved in photosynthesis.



Plant Cells

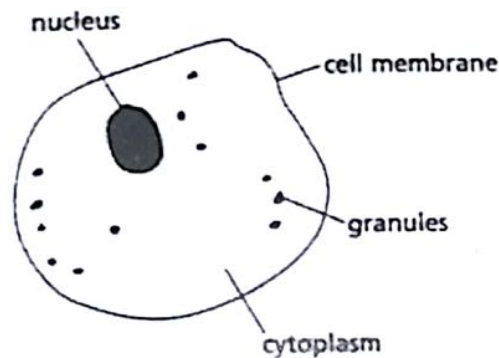
Note: The cell membrane in plants fits tightly against the cell wall, and is often difficult to see.
 Similarities and differences between plant and animal cells are shown in the table below:



Investigation: To observe animal cells

1. Cut a cube of fresh liver, in section, approximately 1.5 cm square.
2. Remove some cells from the cube of liver by scraping one of the cut surfaces with the end of a spatula (the end of a teaspoon would do).
3. Transfer the cells to a clean microscope slide. Add one drop of methylene blue (a suitable stain for animal cells) and one drop of glycerol (glycerine).
4. Stir the cells, stain and glycerol together and leave for 30 seconds. (This time can be adjusted according to the depth of staining required.)
5. Carefully place a clean, dry cover slip over the preparation, then wrap a filter paper around the slide and cover slip.
6. Place the slide on a bench and press hard with your thumb on the filter paper over the cover slip. The filter paper should absorb any surplus stain and glycerol, and the slide is then ready for viewing with a microscope (medium to high power).

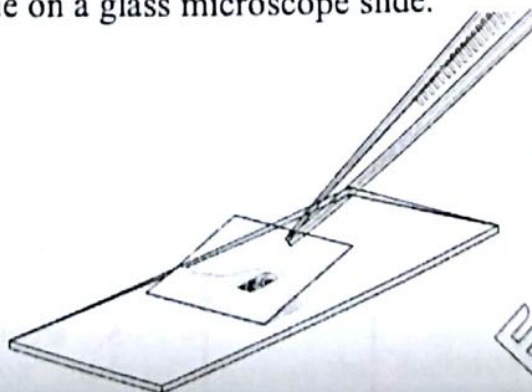
You should be able to see these structures:

**Investigation: To observe a plant cells**

The onion provides a very useful source of epidermal plant tissue which is one cell thick, making it relatively easy to set up as a temporary slide. The onion is made up of fleshy leaves. On the incurve of each leaf there is an epidermal layer which can be peeled off.

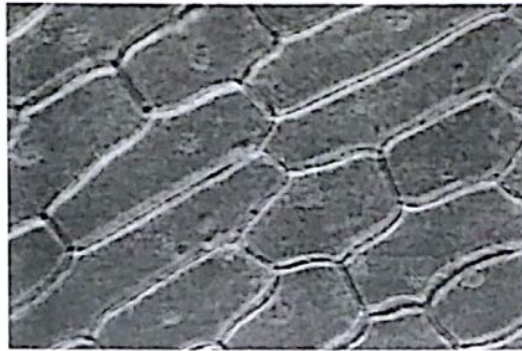


- Using forceps, peel a piece of epidermal tissue from the incurve of an onion bulb leaf.
- Place the epidermal tissue on a glass microscope slide.

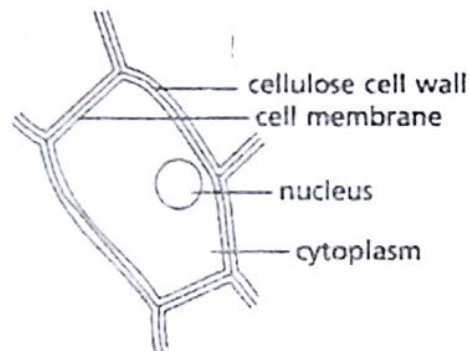


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- Using a scalpel, cut out a 1 cm square of tissue (discarding the rest) and arrange it in the centre of the slide.
- Add two to three drops of iodine solution. (This will stain any starch in the cells and provides a contrast between different components of the cells.)
- Gently lower the coverslip over the onion tissue, trying to avoid trapping any air bubbles. (Air bubbles will reflect light when viewing under the light microscope, obscuring the features you are trying to observe.)
- Leave the slide for about 5 minutes to allow the iodine stain to react with the specimen. The iodine will stain the cell nuclei pale yellow and the starch grains blue.
- Place the slide on to the microscope stage, select the lowest power objective lens and focus on the specimen. Increase the magnification using the other objective lenses. Under high power, the cells should look similar to those shown in figure.



- Make a large drawing of **one** cell and label the following parts: cell wall, cell membrane, cytoplasm and nucleus.



Specialized Cells, Tissues and Organs

In unicellular organisms, one cell must be able to carry out all the functions of a living organism. In multicellular organisms, cells are usually modified to carry out one main function. The appearance of the cell will vary depending on what that main function is therefore it exists a relationship between the structure of a cell and its function.

The following are examples of this relationship.

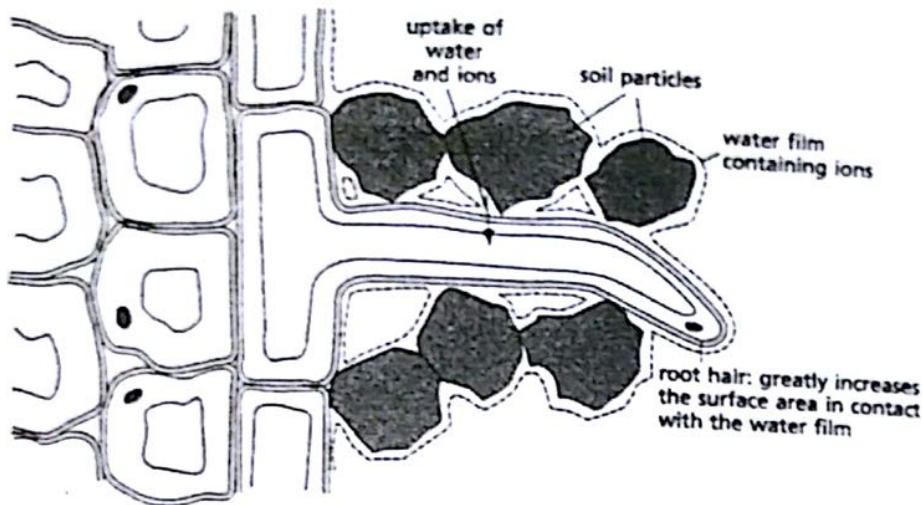
Root hair cell

Function: The **absorption of water and mineral ions** (salts) from the soil.

Adaptation to perform function

The outer part of its cell wall (i.e. the part in direct contact with the soil) is in the form of a long, tubular extension (the **root hair**).

This root hair is able to form very close contact with the water film surrounding many soil particles and greatly increases the surface area of the cell available for uptake of water and ions.



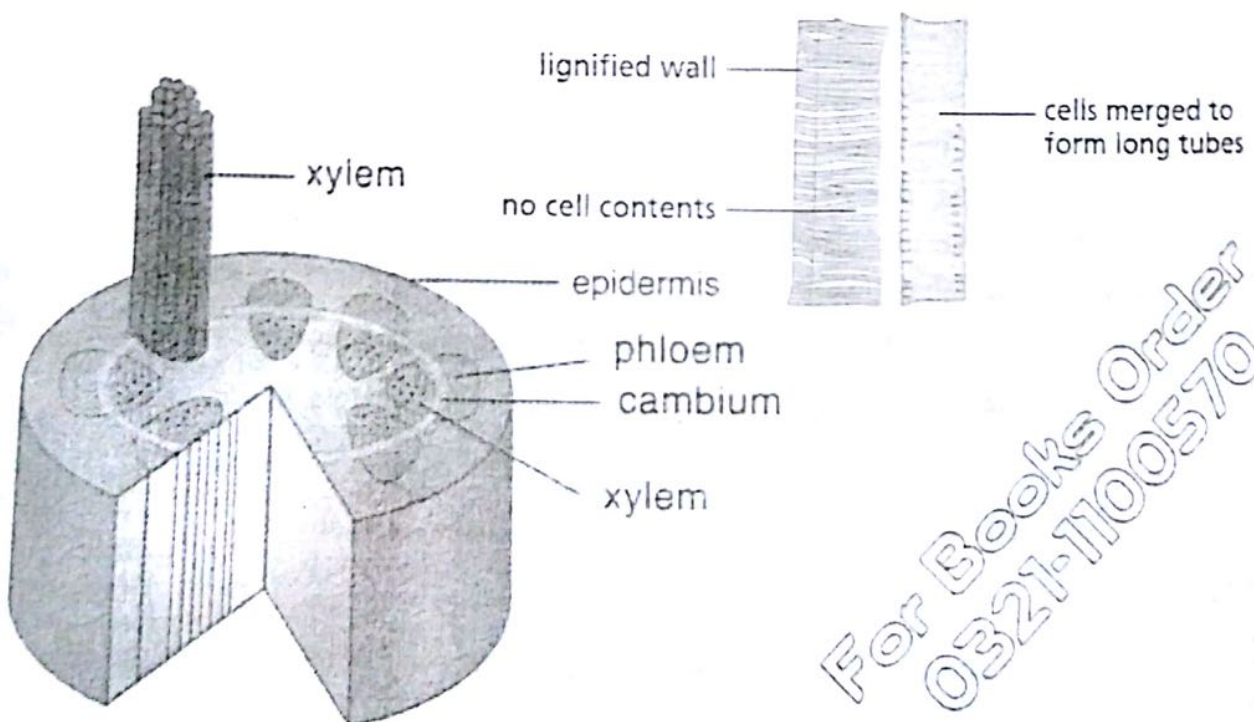
Xylem vessels

Functions: To **conduct water and ions** (dissolved salts) from the roots to the stem, leaves, flowers and fruits and to **provide support** for the parts of the plant above the ground.

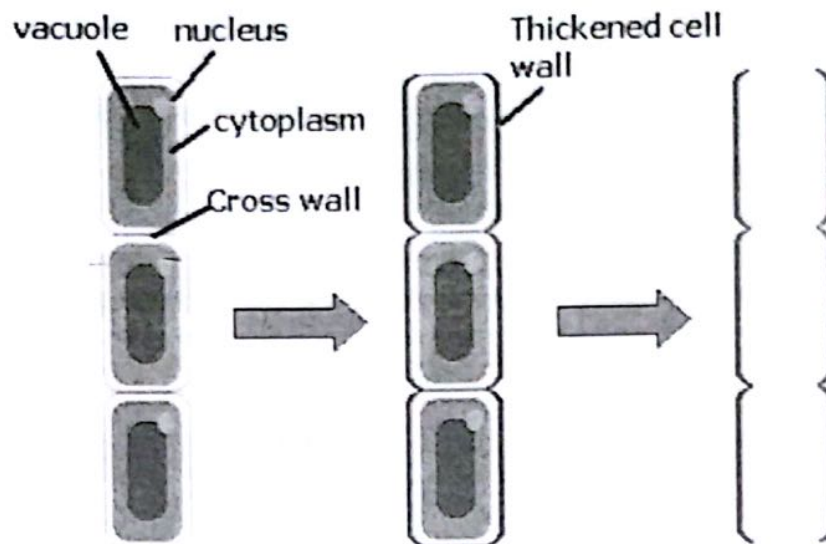
Xylem vessels are part of the vascular bundles which run through the stems of plants like steel reinforcements in concrete pillars. They help to resist bending strains caused by the wind.

Adaptation to perform function

- **Conduction:** xylem vessels are long narrow tubes, stretching from the roots, through the stem, to the leaves. They are stacked end-to-end like drain pipes.
- **Support:** the walls of xylem vessels are strengthened by the chemical lignin. As the lignin in the walls builds up, it eventually kills the xylem vessels. There is therefore no layer of cytoplasm to restrict the flow of water and dissolved salts.



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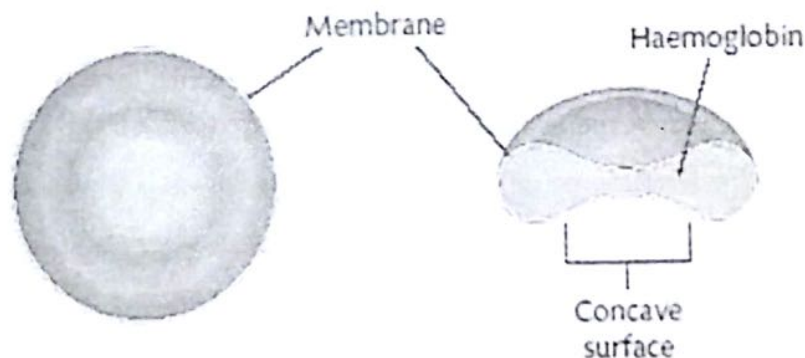


Red blood cells

Function: To carry oxygen around the body.

Adaptation to perform function

- The cytoplasm in red blood cells contains the pigment haemoglobin. Haemoglobin combines with oxygen in the lungs to become oxyhaemoglobin.
- The cells are **small** (7 μm x 2 μm) and there are **many** of them, so they have a **very large surface area** for oxygen absorption.
- They have a **biconcave** shape, making their surface area for absorption even larger.
- They are **flexible**, allowing them to be pushed easily through small blood vessels (capillaries).

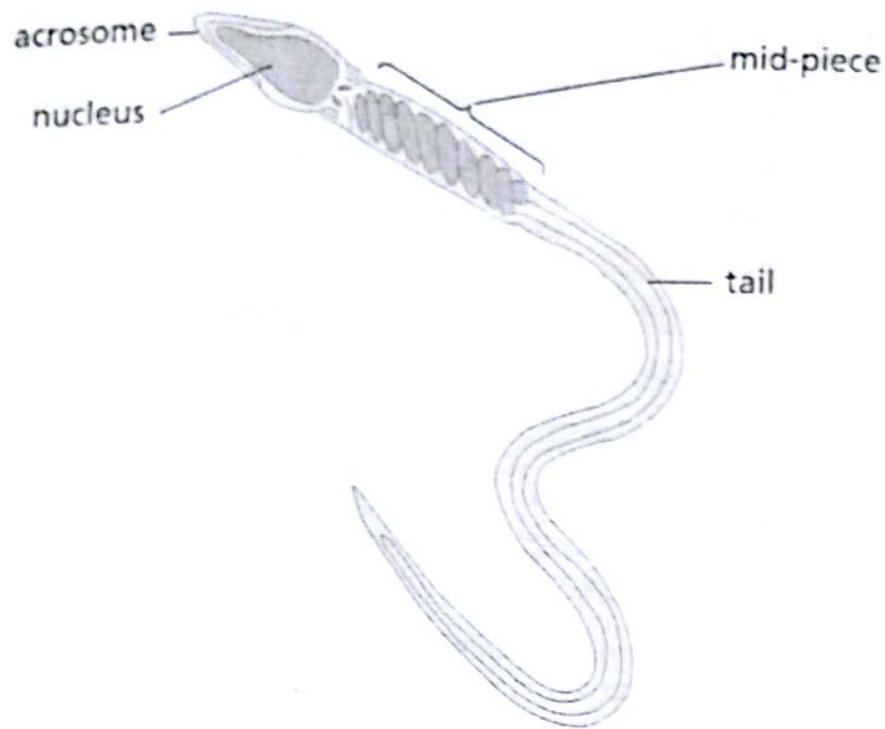


Sperm cells

Function: To fertilize an egg cell during the process of sexual reproduction.

Adaptation to perform function

- The front of cell is oval shaped and contain a nucleus which carries genetic information (haploid number of chromosomes-n).
- Tip – acrosome secrets enzyme to digest the cells around an egg and egg membrane.
- Behind head is a mid-piece which contain a lot of mitochondria to provide energy for movement.
- The tail moves with a whip like action enabling the sperm to swim

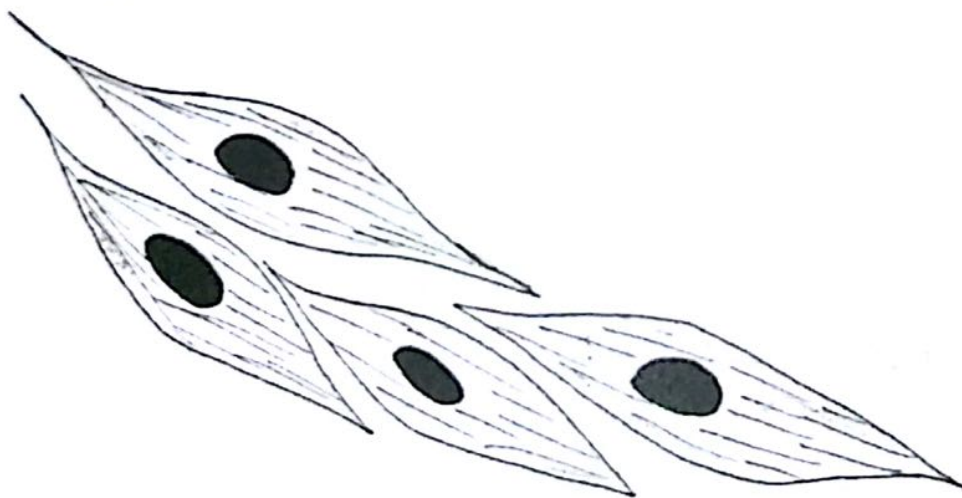


Muscle cells

Function: To cause **movement** when they **contract**. (Contraction brings about a decrease in length of the cell. Muscles can do work *only* when they contract, *never* when they relax.)

How they are adapted to this function

- (i) They are **long** and thin, allowing many to work side-by-side for greater force, or to form a contractile network.
- (ii) Each cell (or 'fibre') contains many smaller **fibrils** – each capable of contracting.
- (iii) Their cytoplasm contains many **mitochondria** (visible only with an electron microscope) which are responsible for releasing **energy** within a cell and necessary here to bring about contraction.



Muscle Cells

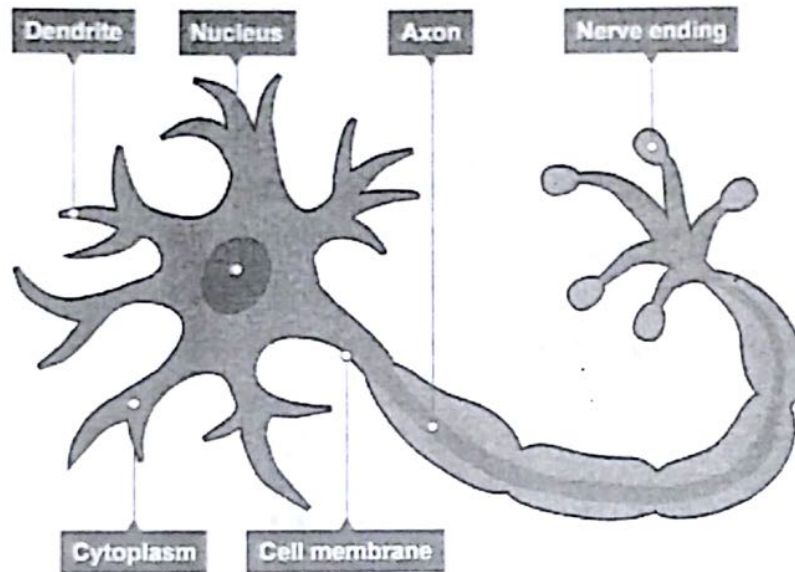
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Nerve Cells

Function: To conduct electrical impulses along the fibre to and from the brain and spinal cord.

How they are adapted to this function

- They are often very long and connects distant parts of the body to central nervous system
- Cell body contains nucleus and fine cytoplasmic processes; these processes are called nerve fibers. These fibers are used to transmit impulses away from cell body (called axon)
- The nerve fibers that conduct impulses towards the cell body are called dendrons.



How cells combine to improve their efficiency

One cell working on its own would achieve very little in an individual plant or animal, so we usually find many similar cells lying side-by-side and working together, performing the same function.

Many similar cells working together and performing the same function are called a **tissue**.

Examples of tissues are **xylem tissue** in the vascular bundles of a plant and **muscular tissue** in the intestine wall of an animal.

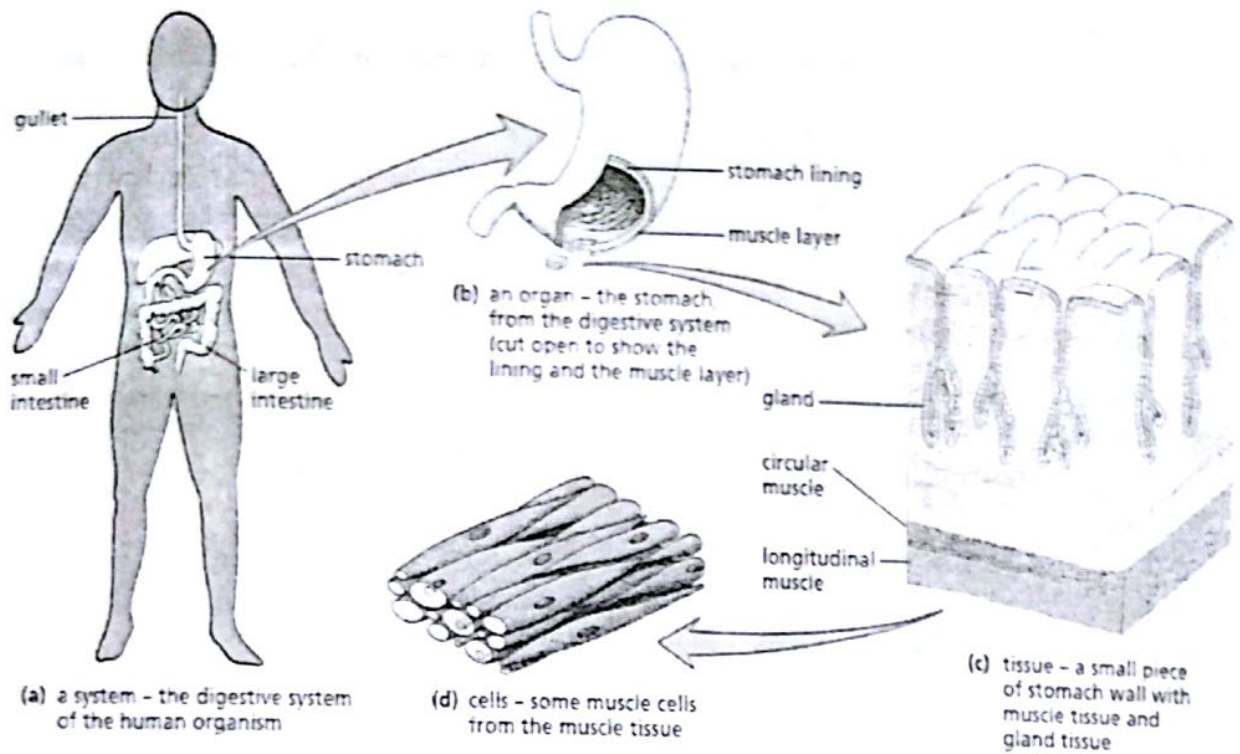
Different types of tissue often work together to achieve a combined function so several tissues working together to produce a particular function form an organism.

Examples of organs are the **leaf of a plant** – an organ for the manufacture of carbohydrates during photosynthesis and the **eye of an animal** – the organ of sight.

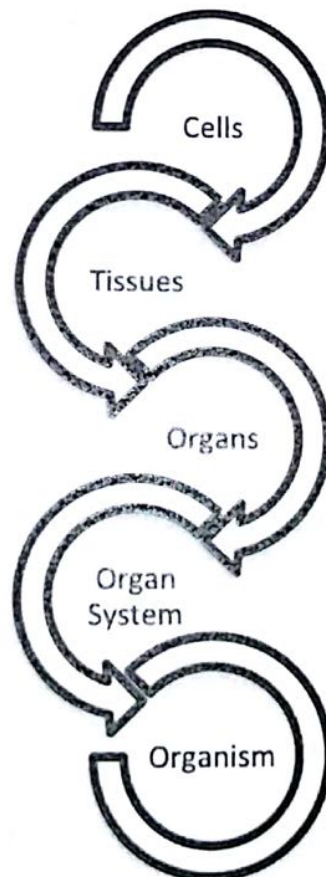
Several different organs may be necessary in order to carry out a particular function. A collection of different organs working together to perform a particular function is called an **organism**.

Examples of organ systems are the **sepals, petals, stamens and carpels** (i.e. the flowers) of a plant – for reproduction (**reproductive system**) and the **heart, arteries, veins and capillaries** in an animal, i.e. the **circulatory system**.

An **organism** is a collection of organ systems working together.



The increasing order of cell organization found within any living organism is as below:



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Syllabus Check List Cell Structure and Organization

After reading chapter are you able to:

- ☐ examine under the microscope an animal cell (e.g. from fresh liver) and a plant cell (e.g. from *Elodea*, a moss, onion epidermis, or any suitable, locally available material), using an appropriate temporary staining technique, such as iodine or methylene blue
- ☐ draw diagrams to represent observations of the plant and animal cells examined above
- ☐ identify, from fresh preparations or on diagrams or photomicrographs, the cell membrane, nucleus and cytoplasm in an animal cell
- ☐ identify, from diagrams or photomicrographs, the cellulose cell wall, cell membrane, sap vacuole, cytoplasm, nucleus and chloroplasts in a plant cell
- ☐ compare the visible differences in structure of the animal and the plant cells examined
- ☐ state the function of the cell membrane in controlling the passage of substances into and out of the cell
- ☐ state the function of the cell wall in maintaining turgor (turgidity) within the cell
- ☐ state, in simple terms, the relationship between cell function and cell structure for the following:
 - absorption – root hair cells
 - conduction and support – xylem vessels
 - transport of oxygen – red blood cells
- ☐ identify these cells from preserved material under the microscope, from diagrams and from photomicrographs
- ☐ differentiate cell, tissue, organ and organ system as illustrated by examples covered in sections 1 to 12, 15 and 16.

O-LEVEL

BIOLOGY

Topic 2:
Diffusion and
Osmosis

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Syllabus 2017 – 2019

Content

2.1 Diffusion

2.2 Osmosis

2.3 Active transport

DIFFUSION AND OSMOSIS

For plants and animals to stay alive, chemicals must be able to move easily and at a faster rate from one part of a cell to another, into and out of a cell and from one cell to another.

It is an advantage to the plant or animal if this chemical movement does not require effort, or more correctly, 'expenditure of energy'. As long as there is no obstruction, chemical molecules carry out this process by **diffusion**.

Before diffusion can occur, there must be a concentration gradient of the molecules – a region of (relatively) **high** concentration to a region of (relatively) **low** concentration.

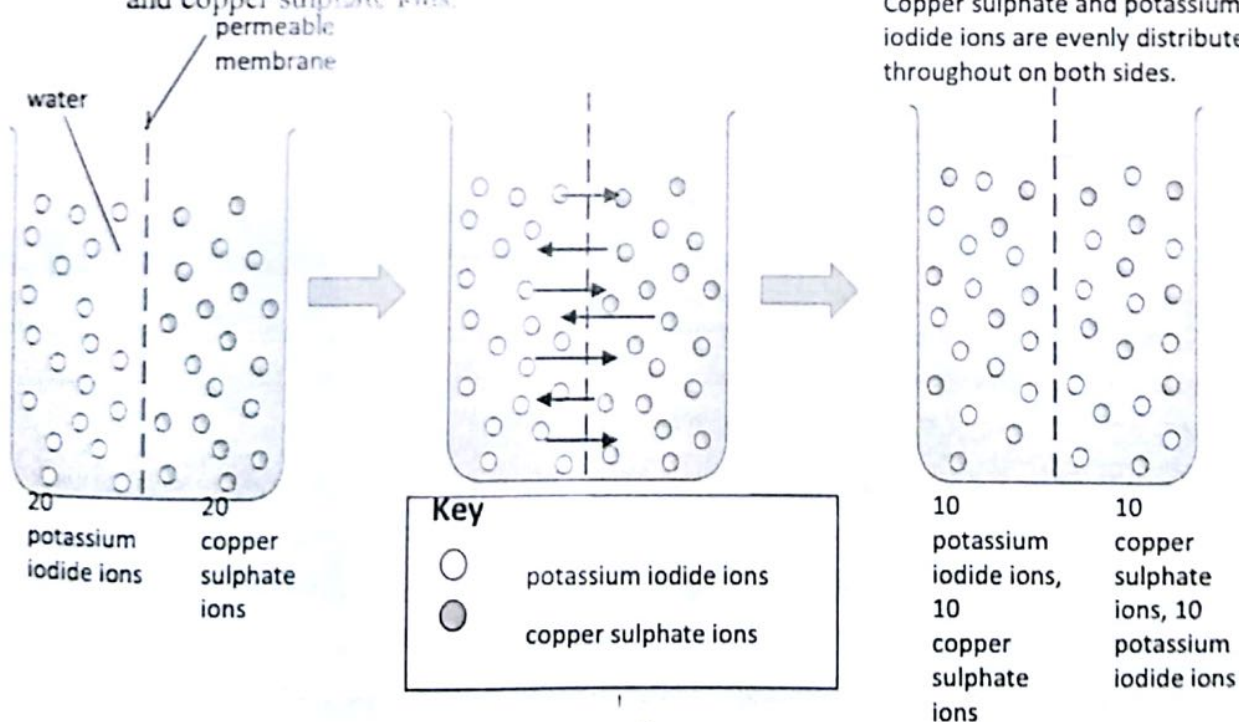
Diffusion is the movement of molecules from a region of higher concentration to a region of lower concentration, down a concentration gradient.

Example of diffusion in plants: The movement of carbon dioxide during photosynthesis. Carbon dioxide, in solution, moves from the water film surrounding the mesophyll cells inside a leaf, to the chloroplasts in the leaf. The movement of water vapour during transpiration. Water vapour moves from the water film surrounding the mesophyll cells inside a leaf, through the intercellular spaces of the leaf, and out through the stomata.

Example of diffusion in animals include: The movement of oxygen into the blood for respiration. Oxygen is dissolved in the moisture lining the air sacs of the lungs (alveoli), then moves through the walls of the alveoli into the blood. The movement of carbon dioxide into the blood. Carbon dioxide, in solution, moves from the cells, through tissue fluid, into the blood in capillaries.

Describing the movement of molecules by diffusion

1. Suppose a container is divided into two sections using a permeable membrane.
2. A solution containing 20 potassium iodide ions in water, is poured into one side of the container and a solution containing 20 copper sulphate ions in water, is poured into the other side. The container is left to stand for a few minutes.
3. When checked, Copper sulphate and potassium iodide ions are evenly distributed throughout on both sides. Each side has the **same concentration** of potassium iodide and copper sulphate ions.

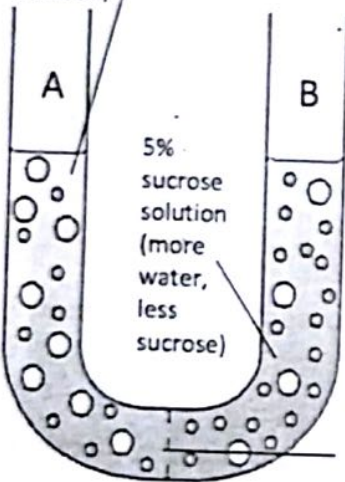


By diffusion, both the potassium iodide and copper sulphate ions moved down their respective concentration gradients, until both sides were at the same concentration. Permeable membrane did not obstruct the movement of the ions in either direction.

The movement of molecules by osmosis

1. Suppose a container is divided into two sections using a **partially permeable membrane** with microscopic holes.
2. 10% sucrose solution (**Concentrated**, less water; more sucrose) is poured into one side, and 5% sucrose solution (**Dilute**, more water; less sucrose) is poured into the other side. Again, the container is left to stand for a few minutes.
3. When checked, the dilute solution has **lost water molecules**, thus becoming more concentrated, while the concentrated solution has **gained water molecules** and become more dilute. Resulting in the level of concentrated solution side raised and lowered the level of other side.

10% sucrose solution
(less water, more
sucrose)



5%
sucrose
solution
(more
water,
less
sucrose)

partially
permeable
membrane

8 sucrose
molecules,
9 water
molecules

4 sucrose
molecules,
18 water
molecules

Key

- sucrose molecule
- water molecule
- ← Net movement of water molecules

8 sucrose
molecules,
18 water
molecules

4 sucrose
molecules,
9 water
molecules

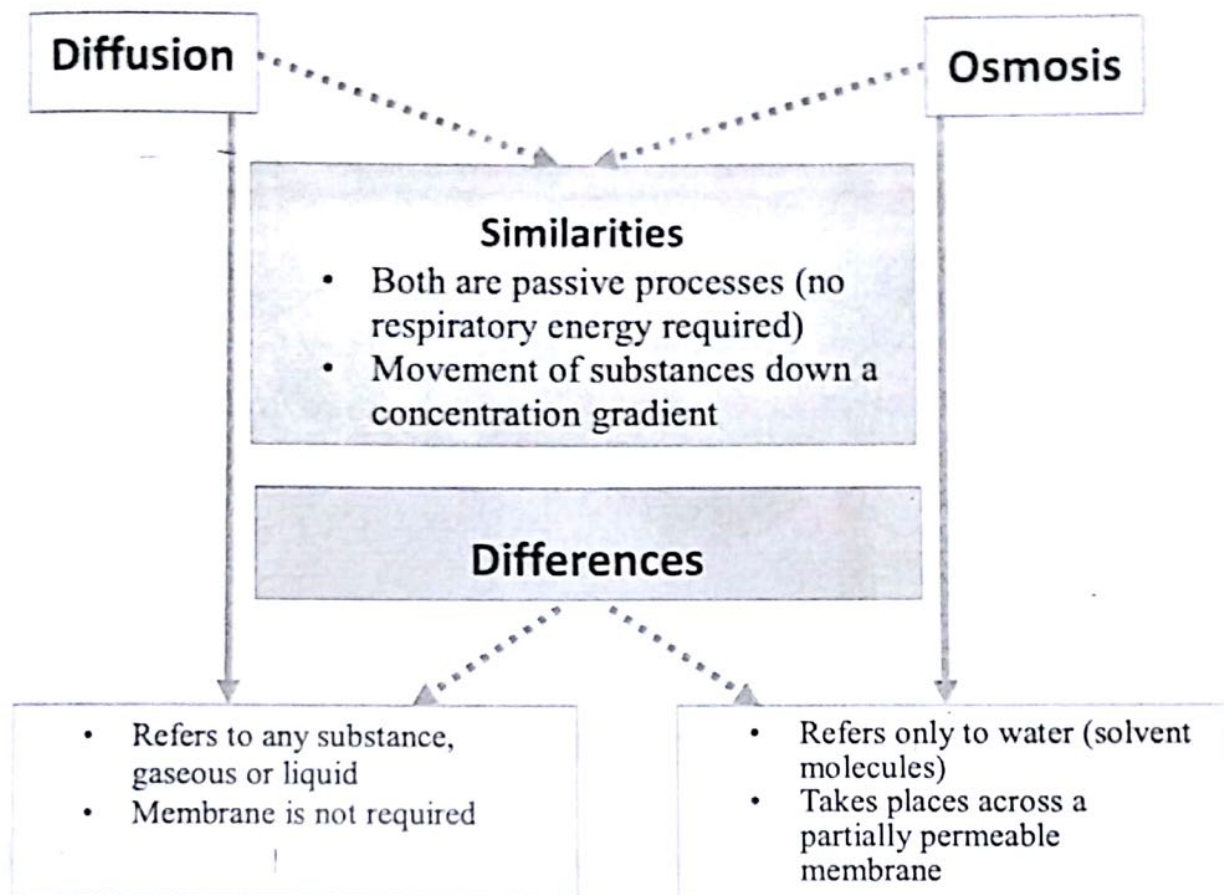
The microscopic holes of the membrane were so small that they allowed the passage of water molecules but not the sugar molecules. The water molecules diffused down their concentration gradient, while the sugar molecules stayed where they were.

This specialised case of diffusion is called **osmosis**, and the separating membrane is described as **partially permeable**.

Dilute solutions, which have a relatively large number of water molecules, are said to have a high water potential.

Concentrated solutions, with fewer water molecules, are said to have a low water potential.

Osmosis can be defined as the passage of water molecules from a region of high water potential, to a region of lower water potential, through a partially permeable membrane.



Water is taken up by a plant

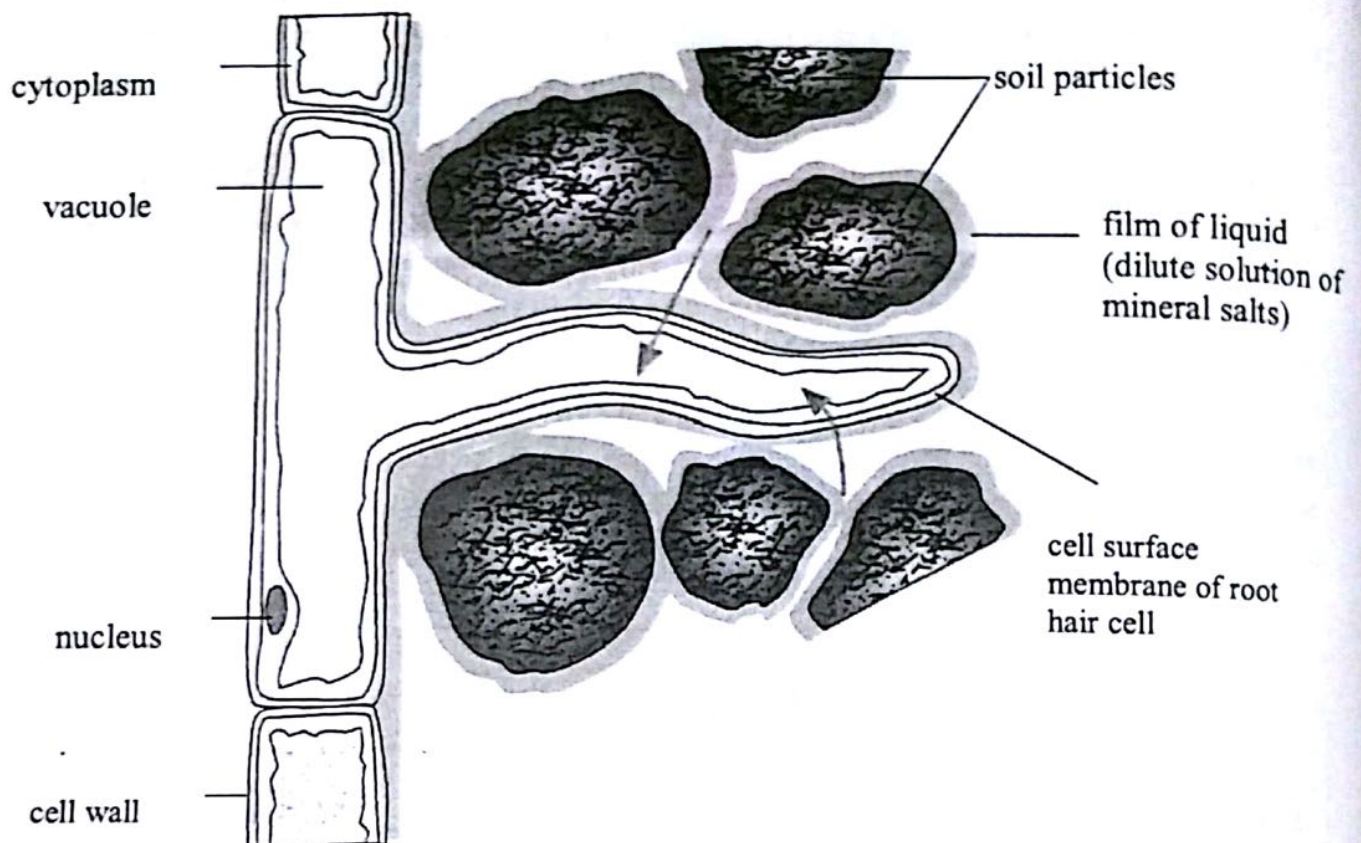
Simple diffusion

1. The cell wall of a root hair cell is made of cellulose, a **completely permeable** substance.
2. The cell wall **does not obstruct** the passage of water into the root hair cell.
3. Where the walls of neighboring cells **touch**, water can pass into the root by simple diffusion – **through** the cellulose of the cell walls (the 'cell wall' pathway).

Osmosis

1. All cell membranes are **partially permeable**.
2. The cell sap of root hair cells has a relatively **low** water potential.
3. Soil water has a relatively **high** water potential.
4. Water molecules will move into the vacuole of root hairs by **osmosis** (the 'vacuolar' pathway).

When water molecules enter a root hair cell, they **increase** the water potential of that cell. **Osmosis** then causes the water to move from the root hair cell to the next cell, closer to the centre of the root. The water molecules move like this from cell to cell until they reach the **xylem vessels** in the centre of the root, where they are transported away to the stem.



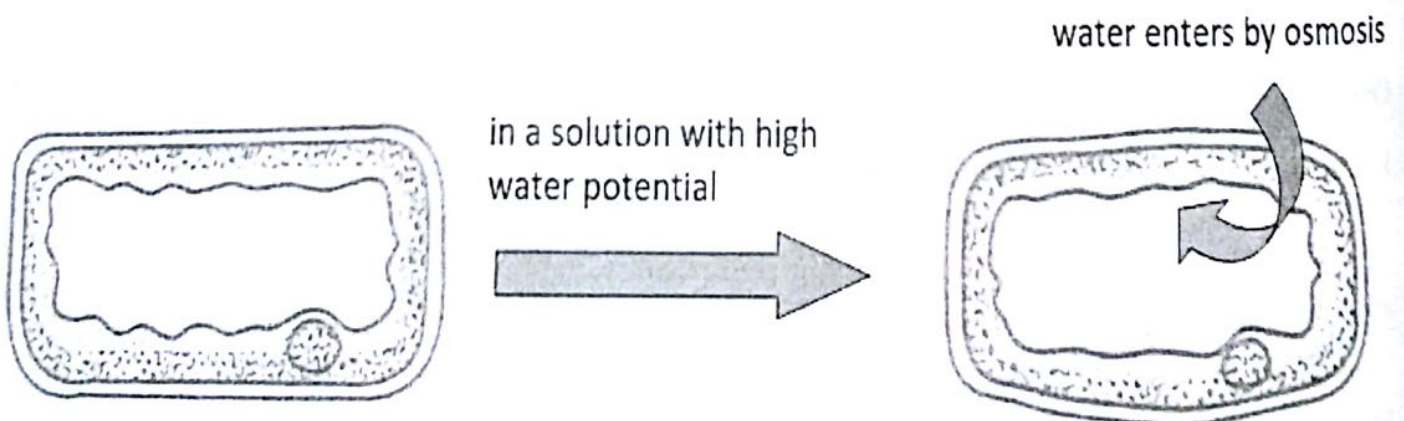
The effect of osmosis on plant and animal cells

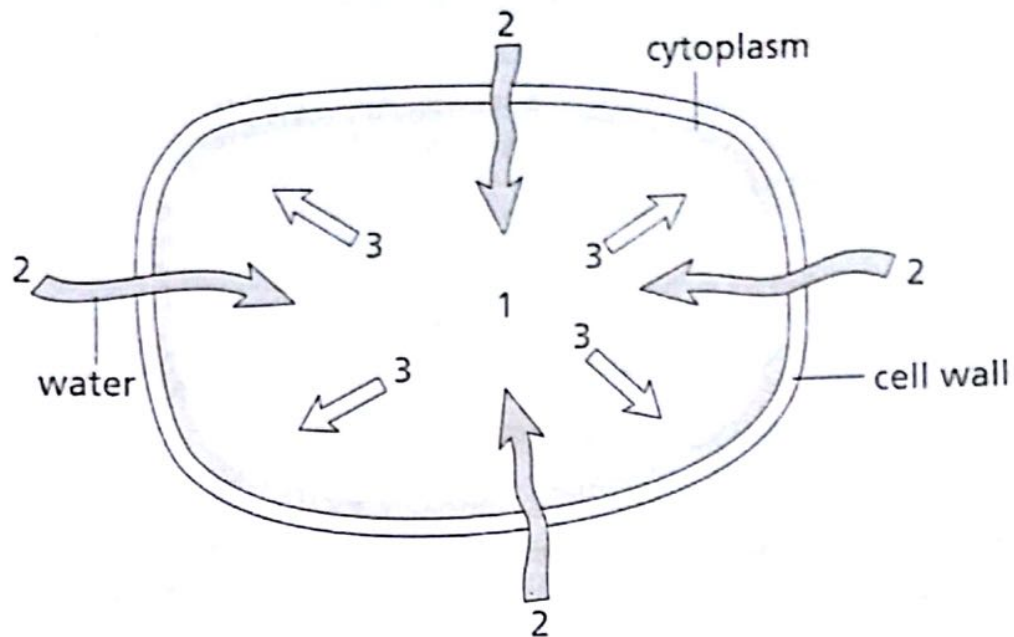
The intake of water by osmosis

Water enters plant (root) cells by osmosis, because the water potential of soil water is usually higher than the water potential of a plant's cell sap. As water enters the plant cell, the vacuole increases in volume. It presses the cytoplasmic lining of the cell against the flexible, box-like cell wall. This pressure is called **TURGOR** pressure, and helps to make plant cells firm.

Turgor, or turgidity, in plant cells helps:

- to keep **stems upright**
- to keep **leaves flat** so they can better absorb sunlight.



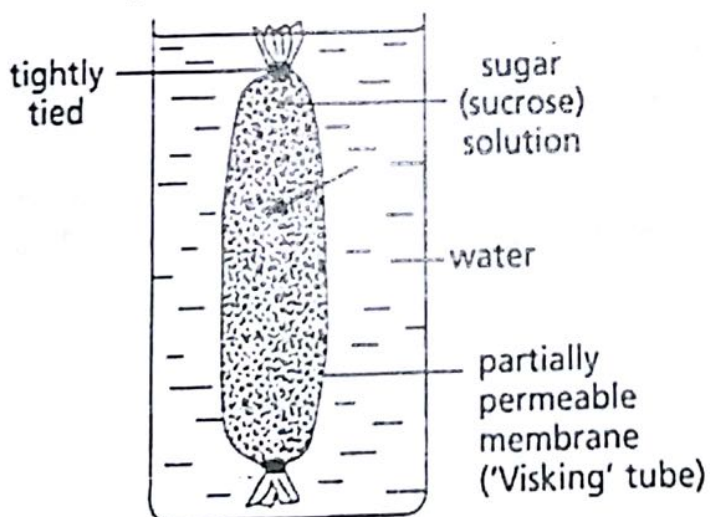


KEY

1. since there is effectively a lower concentration of water in the cell sap
2. water diffuses into the vacuole
3. and makes it push out against cell wall

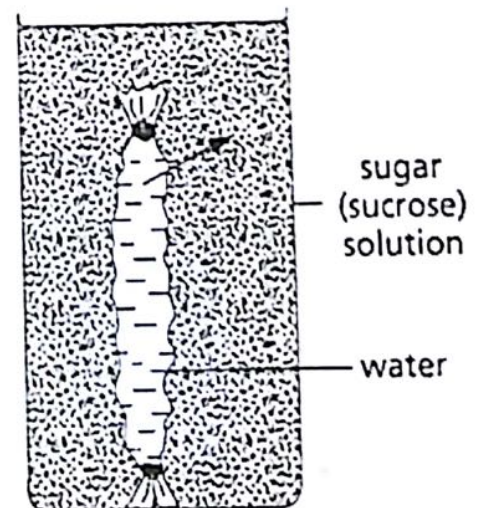
Turgor resulting from osmosis can be demonstrated using a tightly-tied bag made of Visking tube (an artificial partially permeable membrane) filled with sugar solution, and placed in water for 20 minutes.

'Sausage' becomes turgid and swells



water enters
by osmosis

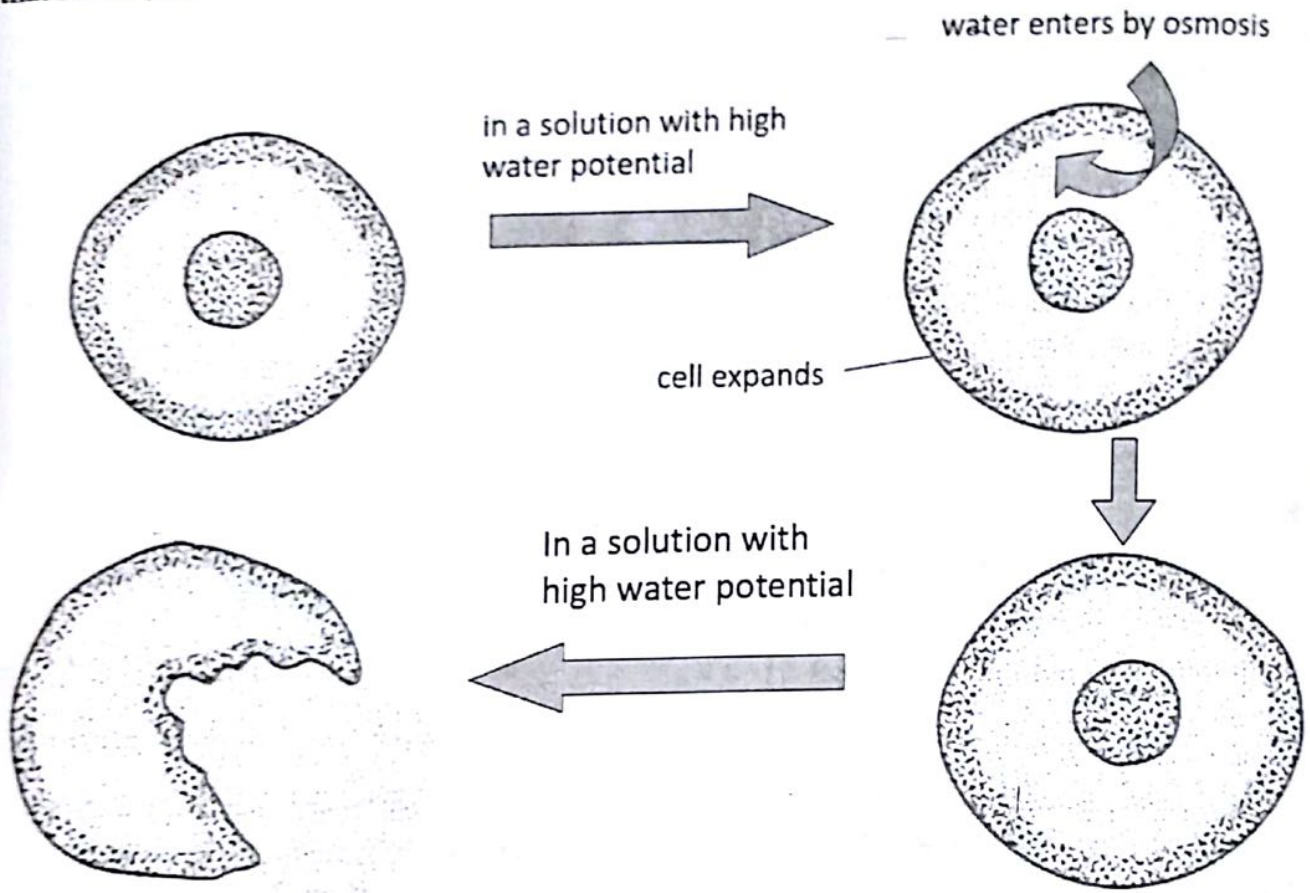
'Sausage' becomes flaccid and shrinks



water leaves
by osmosis

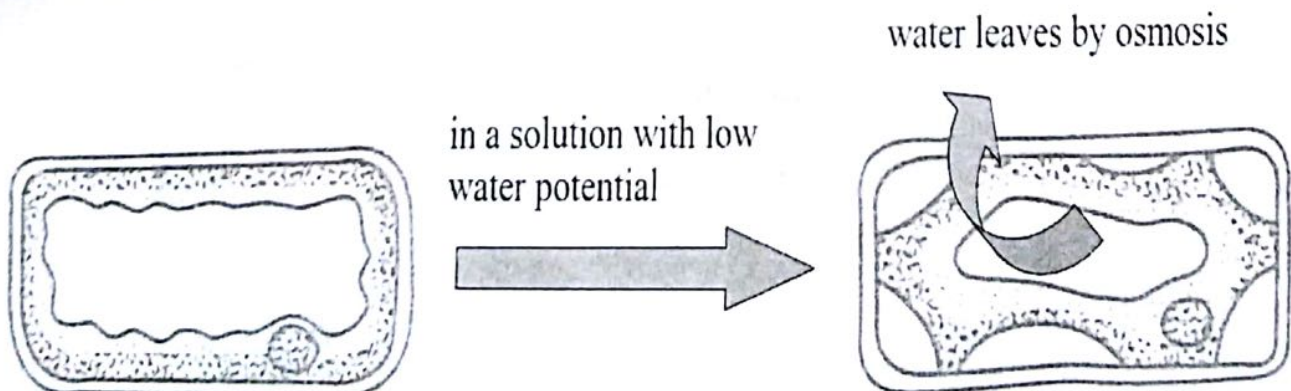
The water potential inside most **animal cells** is often the same as the solution in which the cells are naturally bathed. There is little movement of water by osmosis into or out of the cell.

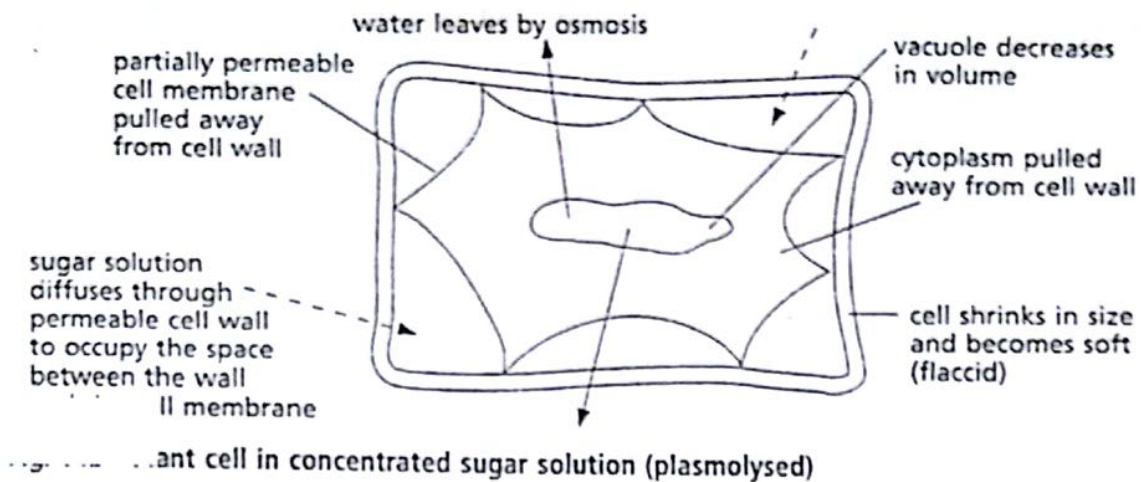
However, if a red blood cell is placed in a solution with a relatively high water potential, it starts to take in water by osmosis. Since there is **no cell wall** to resist the increased pressure that results, the cell **bursts**.



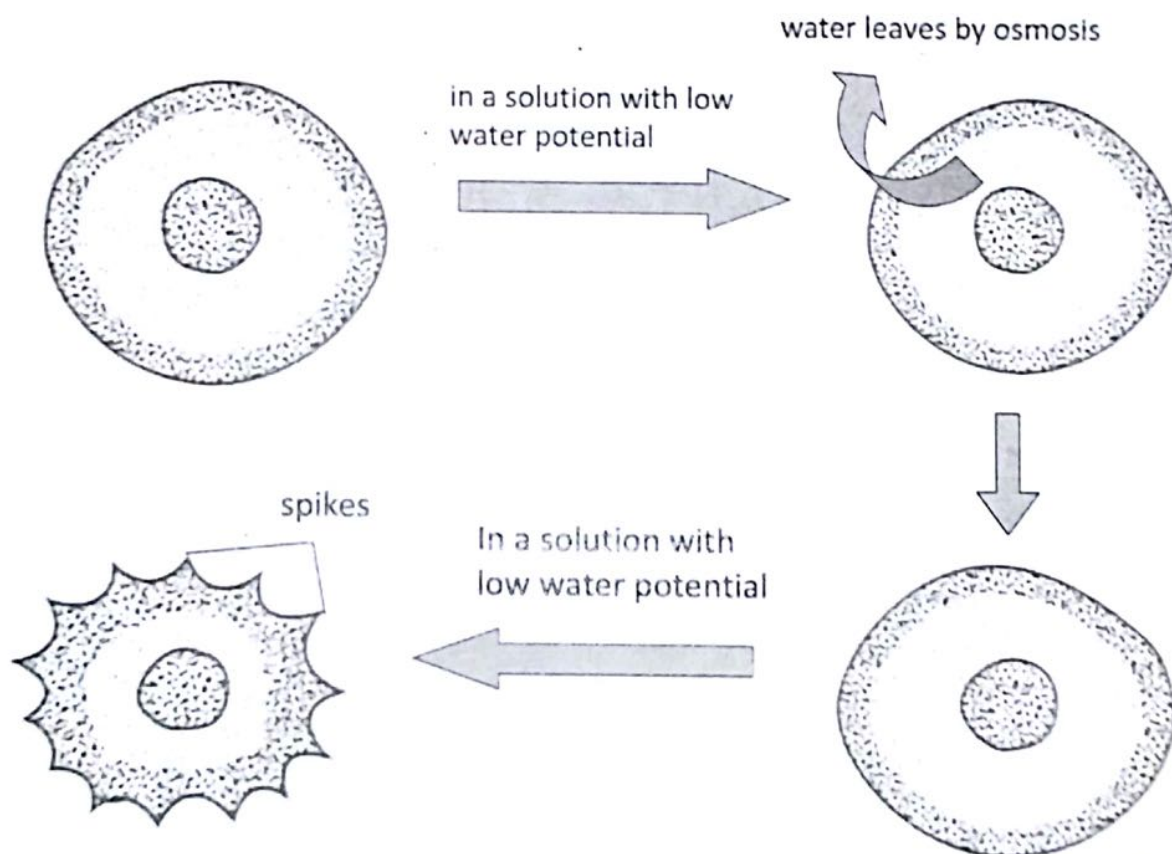
The loss of water by osmosis

Plant cells placed in a solution of relatively low water potential lose water from their vacuoles. The cells lose their turgor because the cytoplasm is no longer being forced against the cell wall. They become flaccid. If the cells remain in the solution of lower water potential, so much water will be drawn from the vacuole that the cytoplasm will pull away from the cell wall. This condition is called **plasmolysis**.





Animal cells placed in solutions of lower water potential lose their shape and turgidity as water moves out of their cytoplasm. A red blood cell shrinks in size and its cell membrane becomes unevenly creased ('crenated').



Active transport

Both plant and animal cells need a range of chemical molecules, other than water, for their metabolism. But these molecules may already be in a higher concentration inside the cell than outside it. In this case, the cell uses a process called **active transport**, where energy is used to move chemicals from an area of lower concentration to an area of higher concentration.

Active transport is an energy-consuming process where substances are transported against a concentration gradient.

The energy required by the cell is provided by the chemical reaction of respiration. Respiration takes place in all living cells.

Examples of active transport:

- In **plant roots**, when the **ions** needed for a plant's metabolism may be in very short supply in the soil water. Ions are absorbed by root hair cells by active transport.
- In the **small intestine** of an **animal**, when digested food (such as **glucose**) is absorbed by the cells of the **villi** by active transport.

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Syllabus Check List Diffusion and Osmosis

After reading chapter are you able to:

- ☐ define diffusion as the movement of molecules from a region of their higher concentration to a region of their lower concentration, down a concentration gradient
- ☐ define osmosis as the passage of water molecules from a region of higher water potential to a region of lower water potential, through a partially permeable membrane
- ☐ describe the importance of a water potential gradient in the uptake of water by plants and the effects of osmosis on plant and animal tissues
- ☐ define active transport as the movement of ions into or out of a cell through the cell membrane, from a region of their lower concentration to a region of their higher concentration against a concentration gradient, using energy released during respiration
- ☐ discuss the importance of active transport as an energy-consuming process by which substances are transported against a concentration gradient, as in ion uptake by root hairs and glucose uptake by cells in the villi.

O-LEVEL BIOLOGY

Topic 3: Enzymes

NOTES BY

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Syllabus 2017 – 2019

Content

- 3.1 Enzyme action
- 3.2 Effects of temperature and pH

ENZYMES

Catalyst is a substance that speed up the rate of a chemical reaction and is not changed by the reaction. They can affect how quickly chemical reactions occur. A minute amount of catalysts are needed to do their job as they are not used up or changed by the reactions they effect, which means they can go on working, continuously catalysing the same reaction, so long as the reactant molecules (the substrate molecules) are present.

Enzymes are protein in nature and act as biological catalysts and all the chemical reactions occurring within the cytoplasm of cells are also under the control of these biological catalysts. Special properties of enzymes includes:

- (i) They are all protein molecules.
- (ii) They are made in the cytoplasm under instruction from genes on the chromosomes in the nucleus.
- (iii) Each enzyme has a unique shape.
- (iv) Enzymes speed up the chemical reactions by lowering the activation energy needed to start the reaction.
- (v) They can either breakdown complex substances into simpler substances (**catabolism**; refer to fig. 4.3) or built up complex substances from simpler substances (**anabolism** refer to Fig. 4.4). The function of an enzyme (e.g. those used in digestion/respiration) is often to break down a large molecule (the substrate molecule) into smaller molecules (the product) or (e.g. those used in photosynthesis) to assemble smaller molecules (the substrate molecules) to a larger molecule (the product).
- (vi) Each enzyme works at its fastest rate at one particular **temperature**. This is known as its **optimum temperature**. For most enzymes in a mammal's body, the optimum temperature is around 37°C . As the temperature rises towards 37°C , the rate of enzyme activity speeds up. If the temperature rises above the optimum, the rate of activity begins to slow down. At around 60°C , the enzyme is **destroyed** or '**denatured**' (not 'killed' - it was never alive). The rate of the reaction falls to (almost) 0.

The 3D shape of the active site is determined by weak hydrogen bonds that hold the chains of amino acids in place. An increase in temperature causes the vibrations in the atoms of enzymes and causes the hydrogen bonds to be disrupted or broken. As a result of this active site loses its shape and is no longer complementary to the substrate. The enzyme can no longer act as a catalyst.

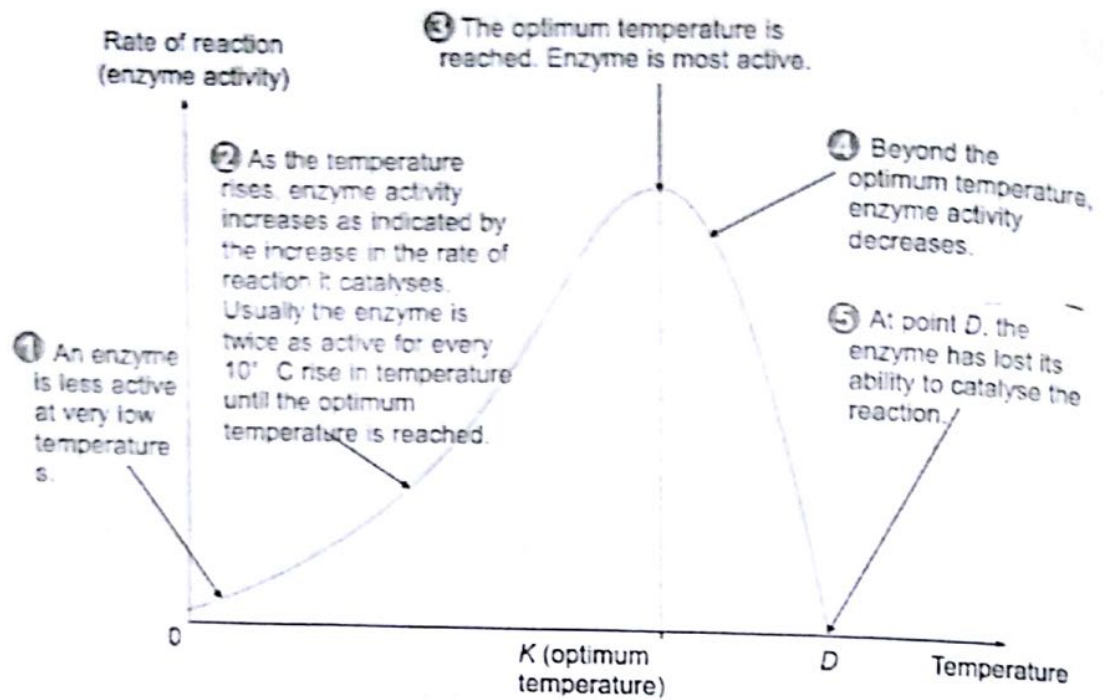


Figure 4.1 Effect of temperature on enzyme activity

- (vii) **Enzyme also works at its fastest rate at optimum pH.** If the pH level falls either side of the optimum, the rate of enzyme activity gradually decreases. For most enzymes in a mammal's body, the optimum is **pH 7**, or slightly above. However, the optimum for each enzyme depends on where it is found in the body. For example, the enzyme protease found in the stomach, where it is highly acidic, is most effective at the low pH 2.

Interference of H^+ or OH^- ions with the hydrogen bonds causes them to be disrupted. The active site loses its specific shape and is no longer complementary to the substrate means the enzyme is denatured.

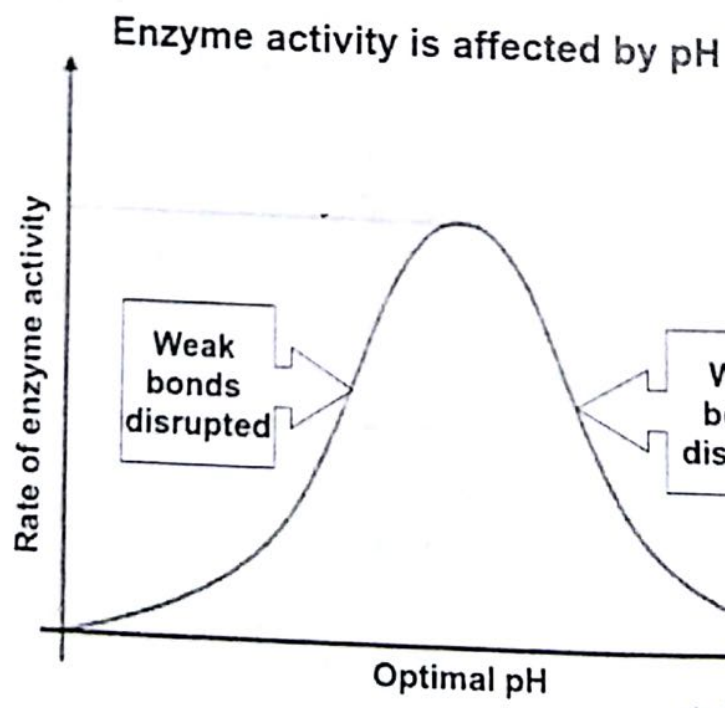


Figure 4.2 effect of pH on enzyme activity

How enzymes work – the 'lock and key' hypothesis

The 'lock and key' hypothesis suggests how this may be achieved.

Each enzyme is a molecule with a **specific shape**. On part of its surface is the **active site** (the 'lock') – a section where its substrate molecule (the 'key') fits exactly. When the substrate molecule is in position in the active site, the enzyme slightly stresses (or 'bends') the substrate, splitting it into two product molecules.

The product molecules drift away from the enzyme molecule, leaving its active site free to operate again.

By including a molecule of water in this process, the newly exposed ends of the product molecules are 'sealed' so they will not re-join. This type of enzyme controlled reaction, common in digestion, is known as hydrolysis.



Figure 4.3 Lock and Key model (Catabolism)

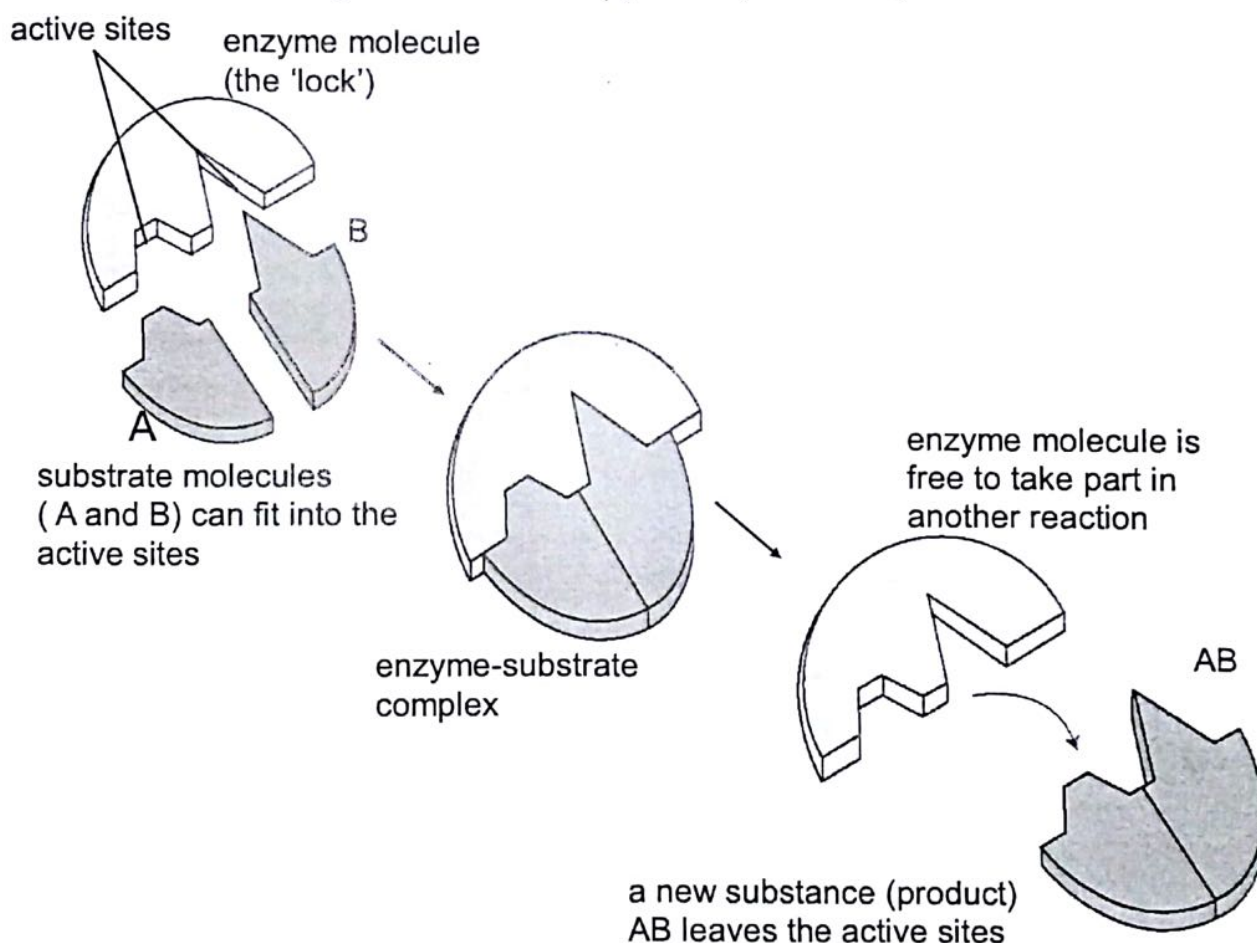


Figure 4.4 Lock and Key model (Anabolism)

The 'lock and key' hypothesis explains enzyme action because:

- (i) Only the correct enzyme-substrate combination can work.
- (ii) Higher temperatures make the enzyme and substrate molecules move more quickly. This also means the substrate molecules enter the active site of the enzyme, and the product molecules leave the active site of the enzyme, more quickly.
- (iii) Extreme heat causes the atoms of the enzyme molecule to move about so violently that they change position relative to one another. This changes the shape of the active site, and the enzyme stops working.
- (iv) Changes in pH may alter the shape of large molecules like proteins. If that protein is an enzyme, the shape of the active site may be changed, and the enzyme will work less efficiently.

Syllabus Check List Enzymes

After reading chapter are you able to:

- ☐ define catalyst as a substance that speeds up a chemical reaction and is not changed by the reaction
- ☐ define enzymes as proteins that function as biological catalysts
- ☐ explain enzyme action in terms of the 'lock and key' hypothesis
- ☐ investigate and describe the effects of temperature and of pH on enzyme activity.

O-LEVEL BIOLOGY

Topic 4: Plant Nutrition

NOTES BY

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Syllabus 2017 – 2019

Content

- 4.1 Photosynthesis
- 4.2 Leaf structure
- 4.3 Mineral nutrition

PLANT NUTRITION

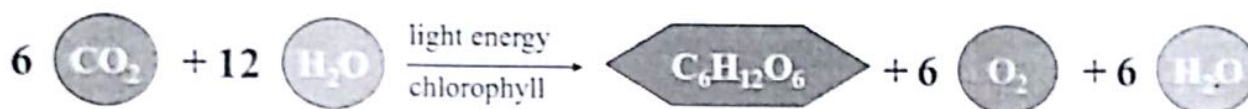
Green plants are described as **autotrophs** ('auto' = self, 'trophic' = feeding). They use small molecules around them (**carbon dioxide** from the **air**, and **water** from the **soil**) to build **large organic molecules** of **glucose** (a carbohydrate) and **oxygen** is also produced in the process. This process occurs during the chemical reaction known as **photosynthesis**.

Photosynthesis

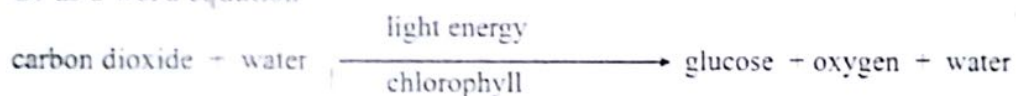
Energy is needed to link the carbon dioxide and water molecules which are used to make carbohydrate. This energy is provided by **sunlight**. Sunlight is **trapped** in a plant by **chlorophyll**. Chlorophyll is a green-coloured chemical that contains **magnesium**. It is found within the **chloroplast** of cells, where photosynthesis takes place.

Through the process of photosynthesis, light energy becomes 'locked away' within the carbohydrate molecule as **chemical energy**.

Overall equation of photosynthesis



Or as a word equation



Photosynthesis is therefore a process in which **light energy is converted into chemical energy**.

If a living organism breaks down the carbohydrate molecule during a metabolic process, the energy is released. Before being broken down, the molecule is often stored by the organism.

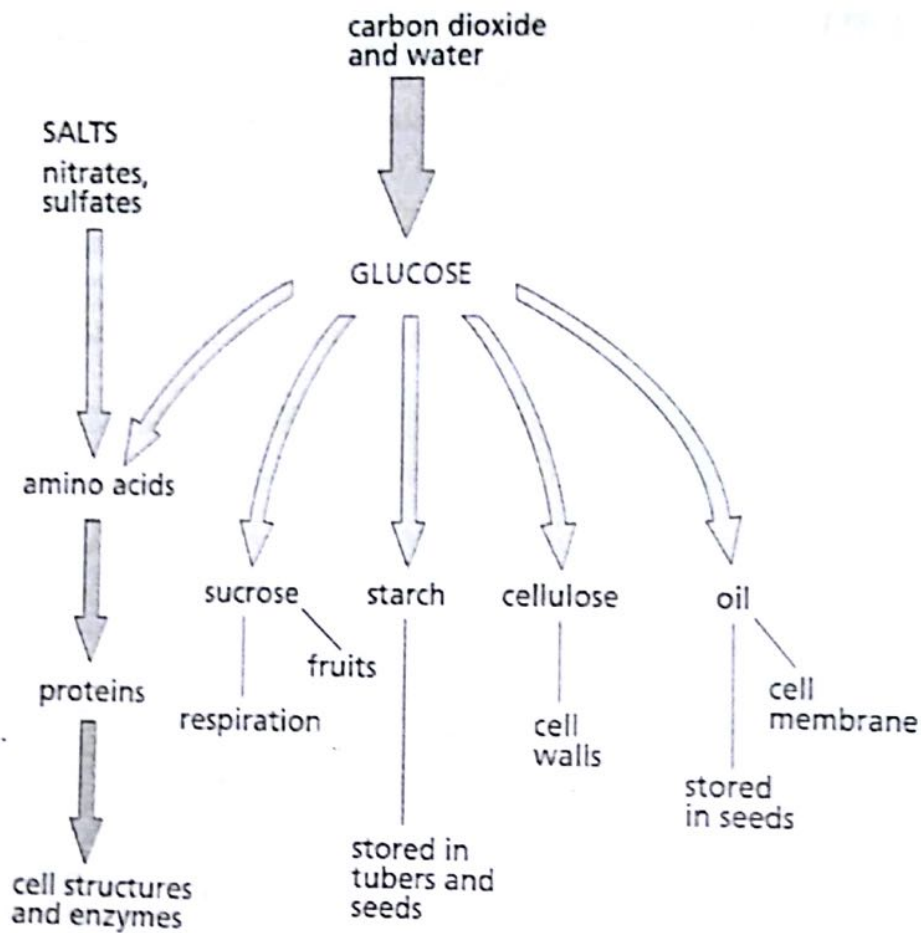
The first carbohydrate made during photosynthesis is glucose. Glucose is a simple sugar is **soluble**. It increases the concentration of the cytoplasm in the cell, which slows down the rate at which enzymes in the cell work. Glucose is therefore usually converted to the insoluble carbohydrate, starch.

Starch is first stored in the **chloroplasts** within the photosynthesizing cells. It is then converted to **sucrose** to be carried to the **storage organs** of a plant. Here, sucrose is converted back to starch. The tuber of a potato is an example of a plant's storage organ.

The importance of photosynthesis

Almost all forms of life rely on the chemical energy found in carbohydrate, the product of photosynthesis. Plants may convert this carbohydrate into protein or fat before it is passed on.

The oxygen produced by photosynthesis is essential for the respiration of most life forms. Photosynthesis also uses up the carbon dioxide released by respiration, converting it into carbohydrate.



How plants obtain raw materials

Roots

Roots absorb the **water** necessary for photosynthesis **from the soil**. Water is carried from the soil to the leaves.

A few millimetres behind the tip of every root, and extending also for a few millimetres, lies the **region of root hairs**. The many root hair cells provide a very **large surface area** for the uptake of water (and of ions) from the soil.

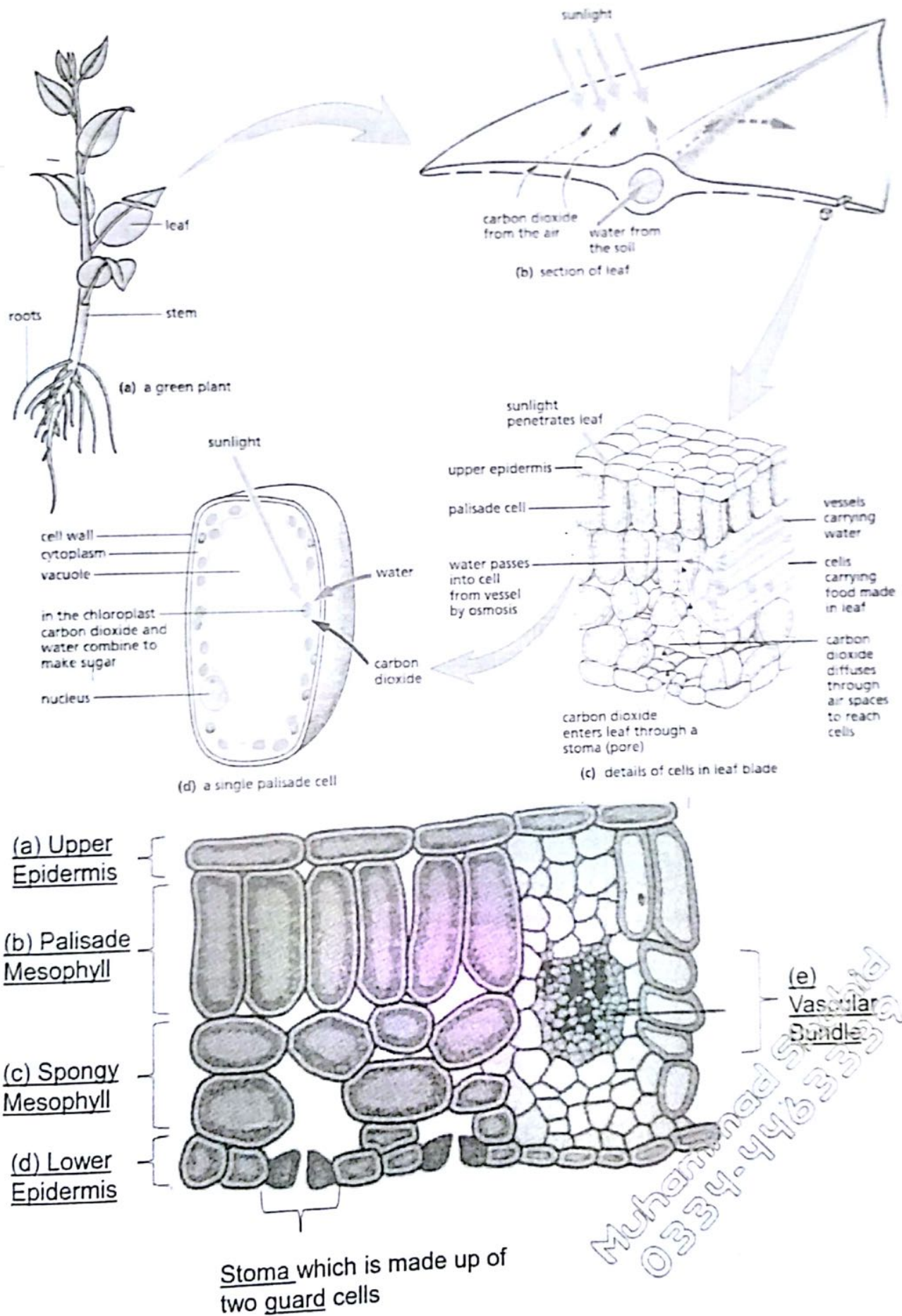
Leaves

In most plants, the leaves:

- absorb carbon dioxide from the air
- absorb sunlight energy
- manufacture carbohydrate
- release the waste product, oxygen.

Most of a plant's photosynthesis takes place in the leaves. Leaves are **organs** containing several different **tissue**. Cells within these tissues are updated to perform a particular function as efficiently as possible.

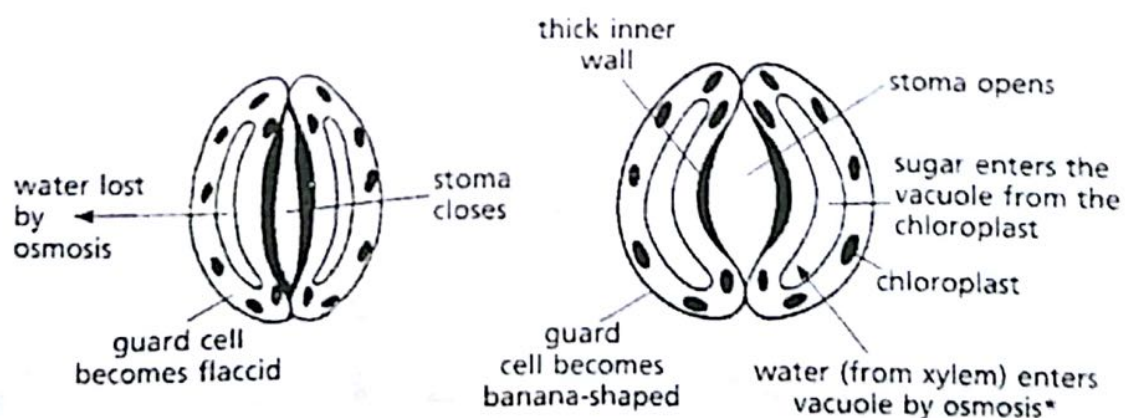
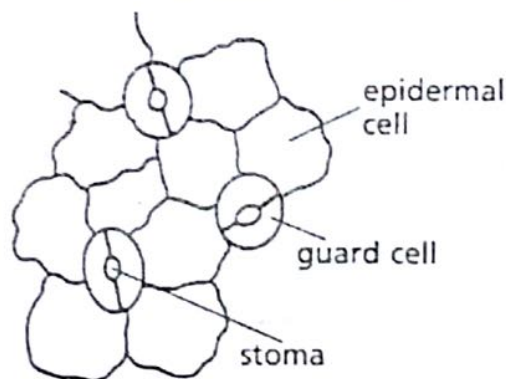
Leaf Internal Structure



How a leaf is adapted for photosynthesis

Structure	Features	Functional adaptations
Cuticle	Waxy non-cellular covering to help protect the leaf.	• Waterproof • transparent to allow light to enter
Upper epidermis	A single layer of cells that secretes the cuticle.	• no chloroplasts, so allowing light to reach the cells beneath
Chloroplasts	Where photosynthesis takes place inside cells.	• contain chlorophyll • large surface area for uptake of carbon dioxide • usually convert glucose to starch and store it temporarily • in dim light, may move nearer to the illuminated surface of the cell
Mesophyll cells	Palisade and spongy cells	• walls have enormous surface area for gaseous exchange – they absorb carbon dioxide and release oxygen during photosynthesis
Palisade cells	Usually one layer of closely-packed, long cells. The first cells to receive light.	• contain largest number of chloroplasts. These are the most active cells in photosynthesis. • walls are coated with a water film
Spongy cells	They: • carry out some photosynthesis • allow gases to freely diffuse throughout the leaf.	• fewer chloroplasts than palisade cells • loosely packed with many air ('intercellular') spaces between them • walls are coated with a water film
Veins (vascular bundles)	Contain xylem and phloem tissues.	
Xylem tissue	Strengthens the leaf, helps to resist tearing . Transports water and ions to the leaf.	• They are dead cells, end-on-end, functioning like long drainpipes
Phloem tissue	Transports dissolved sugar (sucrose) mostly away from the leaf. Transports amino acids to and from leaf.	
Lower epidermis	Layer of cells that forms the lower protective boundary to the leaf.	• may be coated with a thin waxy cuticle

		cells do not contain chloroplasts except the guard cells
Guard cells	Specialised epidermal cells. Control the opening and closing of the stoma between them.	- occur in pairs - control the stoma as a result of their degree of turgidity.
Stoma (plural 'stomata')	Pores that allow: carbon dioxide to enter the leaf for photosynthesis oxygen to leave the leaf during photosynthesis - some exchange of these gases in the opposite direction in low light intensities when the plant is respiring faster than it is photosynthesizing. - Stomata also allow water vapour (a gas) to leave a leaf during transpiration.	



How a leaf is involved in the process of photosynthesis

1. Carbon dioxide **diffuses down a concentration gradient** from the atmosphere, through the stomata, into the leaf.
2. Carbon dioxide diffuses freely throughout the leaf in the intercellular spaces.
3. Carbon dioxide dissolves in the film of water which surrounds the mesophyll cells. The water is delivered to the leaf in the xylem of the vascular bundles.
4. Carbon dioxide diffuses in solution into the mesophyll cells and passes to the chloroplasts, where photosynthesis occurs.
5. Sugar made by photosynthesis is carried away ('trans located') from the leaf in the phloem of the vascular bundles.
6. Oxygen diffuses from the mesophyll cells into the intercellular spaces and out through the stomata, down a concentration gradient into the atmosphere.

Mineral nutrition in a plant

The importance of nitrogen-containing ions

Living organisms need **proteins** for growth and repair. Plants have to manufacture ('synthesize') their own proteins. To do this, they convert their carbohydrates into amino acids, then link the amino acid together to form proteins.

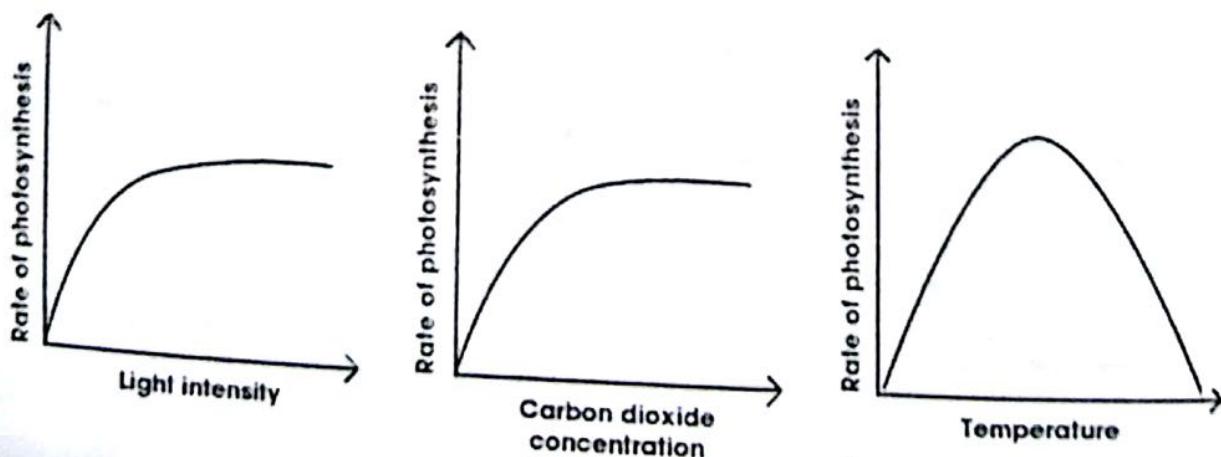
Nitrogen is another element plants need to be able to convert carbohydrate into amino acid. Plants absorb nitrogen, as the nitrate (NO_3^-), **from the soil** through root hairs. Nitrogen makes up about 79% of the atmosphere, but plants cannot make direct use of it in this form.

What does a plant need to photosynthesize?

We can use experiments to show that carbon dioxide, light energy and chlorophyll are necessary for the process of photosynthesis. It is difficult to show that water is necessary for photosynthesis, because the removal of water from a plant may have serious effects on other functions of the plant, not just on photosynthesis.

Limiting factors

The availability of light, carbon dioxide, water and a suitable temperature all affect the rate of photosynthesis. However, the rate of photosynthesis in a plant depends on which one of these factors is in **shortest supply**. That particular factor will limit the rate of photosynthesis, even when all others may be ideal (or 'optimum'). Light, carbon dioxide, water and temperature are therefore **limiting factors**.



The rate of photosynthesis

We can now look at a plant's **rate** of photosynthesis, that is, how quickly it photosynthesizes. This rate changes if we vary levels of certain elements: light, carbon dioxide and temperature. We can demonstrate this in experiments by measuring the release of oxygen by a water plant.

Things to remember when performing experiments

The importance of a control

In the first three experiments given below, a **comparison** is made between a leaf (or part of a leaf) which is able to function **with** all the requirements for photosynthesis, and a leaf (or part of one) where one of the requirements is missing. In this way, the results of the experiment are shown to be **valid**.

The apparatus and materials which provide this comparison make up the **control** to the experiment. Wherever possible, all biological experiments should have a control.

Experimental error

To reduce error, each of the experiments below should be **repeated** several times, if possible. An **average** of the results should then be taken.

Investigation: To show that carbon dioxide is necessary for photosynthesis

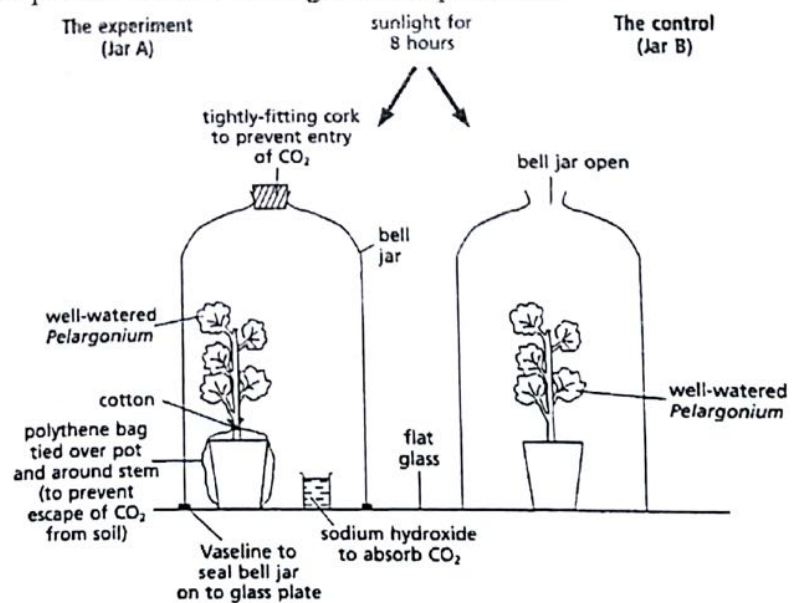
Apparatus

- two well-watered **de-starched** potted plants (e.g. *Pelargonium* or *Coleus*)
- polythene bag to fit over one of the pots
- cotton (to tie the polythene bag over the pot and around the stem)
- a large piece of flat glass
- two bell jars
- petroleum jelly (Vaseline)
- a small beaker containing concentrated sodium hydroxide

Before the experiment, the plants should be kept in a dark place (e.g. a cupboard) for 24-48 hours, so that any starch present in their leaves has been used up. This is important because these types of plants immediately turn any glucose they make during photosynthesis into starch, and we will be testing the leaves after the experiment to see if any starch is present. We must therefore make sure there is no starch present before we begin the experiment.

Method

Set up the experiment as shown.



The two plants are left side-by-side in sunlight. After about **eight hours**, a leaf is taken from each plant and tested for the presence of **starch** as shown on the next page.

The starch test: to show the presence of starch in a leaf

1. Transfer the leaf to a beaker of **boiling water** for about **one minute**.
2. **Turn off the Bunsen burner.**
3. Transfer the leaf to a large test-tube which is half-full of **methylated spirits** (meths).
4. Place the test-tube (with the leaf in the meths) into the recently-boiled water, and allow the heat of the water to bring the meths to the boil. The chlorophyll is removed from the leaf, but the leaf becomes brittle.
5. Remove the leaf from the meths, and raise it in the hot water. This will soften the leaf.
6. Spread the leaf on a white tile and add **iodine solution**.
7. If starch is present, the leaf will turn **blue/black**. If not, it will stain **brown**.

Results

If this procedure is carried out on the two leaves from Jar A and Jar B, the results should be as follows:

Leaf from Jar A stains brown. There is no starch present.

Leaf from Jar B stains blue/black. Starch is present.

Conclusion

Conditions in the two jars were identical, except that only Jar B contained carbon dioxide. Carbon dioxide is necessary for photosynthesis.

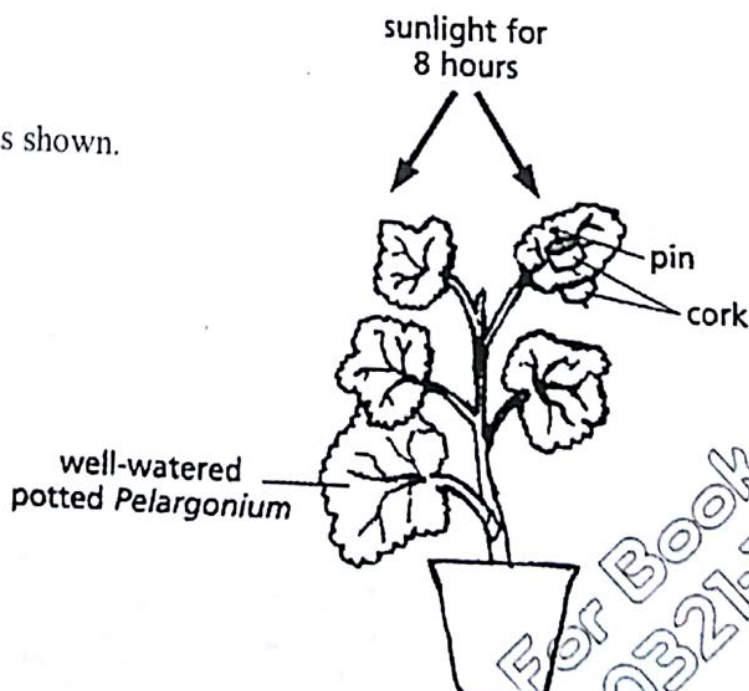
Investigation: To show that **light** is necessary for photosynthesis

Apparatus

- a well-watered, de-starched, potted plant (e.g. *Pelargonium* or *Coleus*)
- a cork cut into two pieces
- a pin

Method

The apparatus is set up as shown.



The experiment is left in sunlight for eight hours.

The cork is removed from the leaf, and the starch test is carried out on the leaf.

The starch test: to show the presence of starch in a leaf

1. Transfer the leaf to a beaker of **boiling water** for about **one** minute.
2. **Turn off the Bunsen burner.**
3. Transfer the leaf to a large test-tube which is half-full of **methyated spirits** (meths).
4. Place the test-tube (with the leaf in the meths) into the recently-boiled water, and allow the heat of the water to bring the meths to the boil. The chlorophyll is removed from the leaf, but the leaf becomes brittle.
5. Remove the leaf from the meths, and raise it in the hot water. This will soften the leaf.
6. Spread the leaf on a white tile and add **iodine solution**.
7. If starch is present, the leaf will turn **blue/black**. If not, it will stain **brown**.

Results

Where the cork covered the leaf, the leaf stains **brown**. The rest of the leaf stains **blue/black**.

Conclusion

Starch is produced only in areas of the leaf where light is able to reach. Light is necessary for photosynthesis.

Investigation: To show that chlorophyll is necessary for photosynthesis

Apparatus

- a potted plant (e.g. *Pelargonium* or *Coleus*) that is well-watered, de-starched and **variegated**

A 'variegated' plant has leaves one part of which are green (where chlorophyll is present) and the rest contains no chlorophyll (and is, therefore, often white).

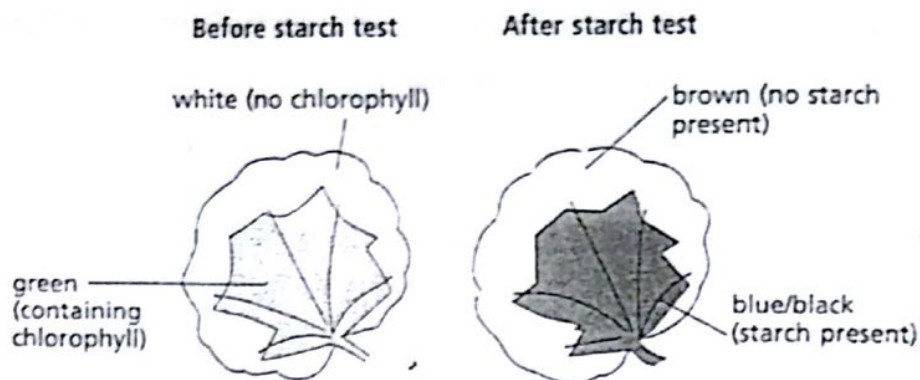
Method

Leave the plant in sunlight for eight hours. Remove one leaf and carry out the starch test.

The starch test: to show the presence of starch in a leaf

1. Transfer the leaf to a beaker of **boiling water** for about **one** minute.
2. **Turn off the Bunsen burner.**
3. Transfer the leaf to a large test-tube which is half-full of **methyated spirits** (meths).
4. Place the test-tube (with the leaf in the meths) into the recently-boiled water, and allow the heat of the water to bring the meths to the boil. The chlorophyll is removed from the leaf, but the leaf becomes brittle.
5. Remove the leaf from the meths, and raise it in the hot water. This will soften the leaf.
6. Spread the leaf on a white tile and add **iodine solution**.
7. If starch is present, the leaf will turn **blue/black**. If not, it will stain **brown**.

Results



Conclusion

Starch is made only in areas of the leaf where chlorophyll is present. Chlorophyll is necessary for photosynthesis.

Waste product of photosynthesis

After carrying out the three experiments described above, we can deduce that carbohydrate (starch) is produced when a plant has access to carbon dioxide, sunlight and chlorophyll.

However, there is also a **waste product** of the process. This can be shown if a water plant is allowed to photosynthesis in the laboratory. Water plants such as *Elodea* or *Hydrilla* may be used for these investigations.

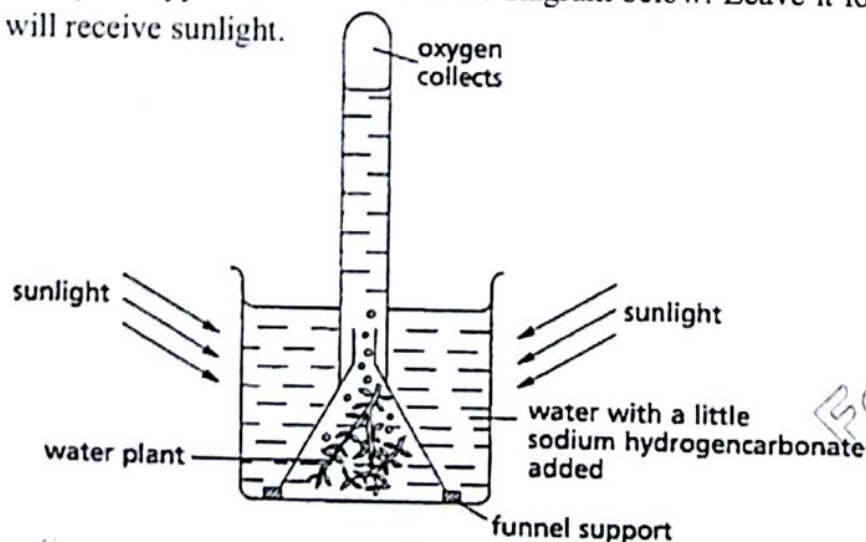
Investigation: To show that oxygen is given off during photosynthesis

Apparatus

- large beaker
- short-stemmed funnel
- two thick coins (to act as funnel supports)
- sodium hydrogencarbonate powder (to supply carbon dioxide to the plant)
- test-tube
- water plant (e.g. *Elodea* or *Hydrilla*)

Method

Set up the apparatus as shown in the diagram below. Leave it for two days in a place where it will receive sunlight.



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Results

A gas collects at the top of the test tube which is found to **re-light a glowing splint**.

Conclusion

Only oxygen has the power to re-light a glowing splint, so oxygen has been released during photosynthesis.

The **Control** for this experiment is to set up the same experiment in a dark cupboard, for the same length of time. No gas collects in the test tube.

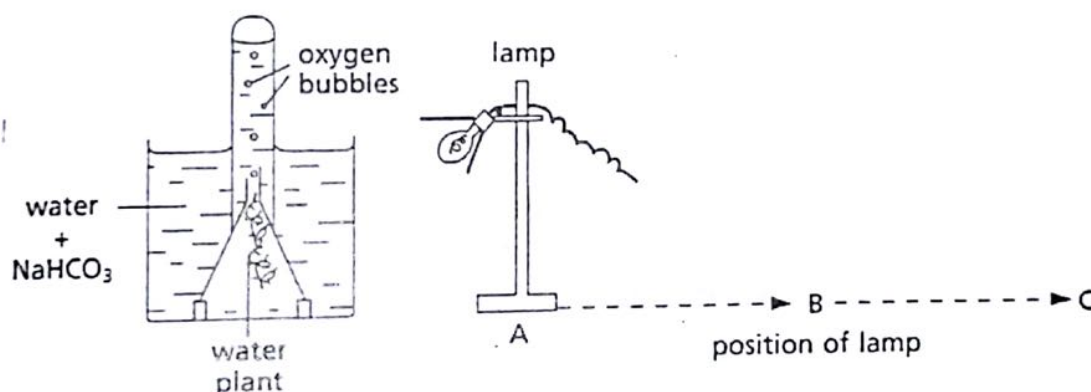
Investigation: To show the effect of varying light intensity on the rate of photosynthesis

Apparatus

- a large test-tube
- a bench lamp
- a length of stem from a water plant (e.g. *Elodea* or *Hydrilla*)
- a timer

Method

The apparatus is set up as shown in Fig. 22. It is better to carry out this experiment in a darkened room so that the only source of light reaching the plant is the bench lamp.



As the water plant photosynthesises, bubbles are released from the cut end of the stem. Place the bench lamp at position A. leave the plant for about 10 minutes – this allows the plant time to adjust to the conditions. Count the number of bubbles released by the plant for a measured period of time (e.g. 3 minutes). Record the results.

Move the lamp to position B. again leave the plant for 10 minutes, then count the bubbles released by the plant for the same length of time and record the results.

Move the lamp to position C, and repeat the procedure.

Results

As the lamp is moved further away from the plant, the intensity of light reaching the plant decreases. As the light intensity decreases, so does the number of bubbles released by the cut stem over the same period of time.

Conclusion

The rate of photosynthesis decreases with decreased light intensity.

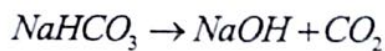
Investigation: To show the effect of varying the carbon dioxide concentration on the rate of photosynthesis

Apparatus

- a large test-tube
- a bench lamp
- a length of stem from a water plant (e.g. *Elodea* or *Hydrilla*)
- a timer
- sodium hydrogencarbonate powder

Method

When sodium hydrogencarbonate dissolves in water, it supplies the water with carbon dioxide:



Immerse the length of stem in a test-tube filled with tap water. The water should be at room temperature. Leave it for about 20 minutes so the plant stem can adjust to the conditions. Place a bench lamp about 25 cm away and direct it at the plant. Count the number of bubbles released by the stem over a period of 3 minutes, and record the results.

Carefully weigh out 0.25 g of sodium hydrogencarbonate and add it to the water in the test-tube. Gently shake the tube to dissolve the powder, then leave for 20 minutes. Again, place the bench lamp about 25 cm away from the plant, and count the number of bubbles over 3 minutes. Repeat this process twice, adding a further 0.25 g of hydrogencarbonate each time.

Results

More carbon dioxide becomes available to the plant as more sodium hydrogencarbonate is added to the water. As the amount of carbon dioxide increases, so does the number of bubbles released by the stem, measured over the same period of time.

Conclusion

As the amount of carbon dioxide available to the plant increases, so does the amount of carbon dioxide released from it. The increased amounts of available carbon dioxide therefore increase the rate of photosynthesis.

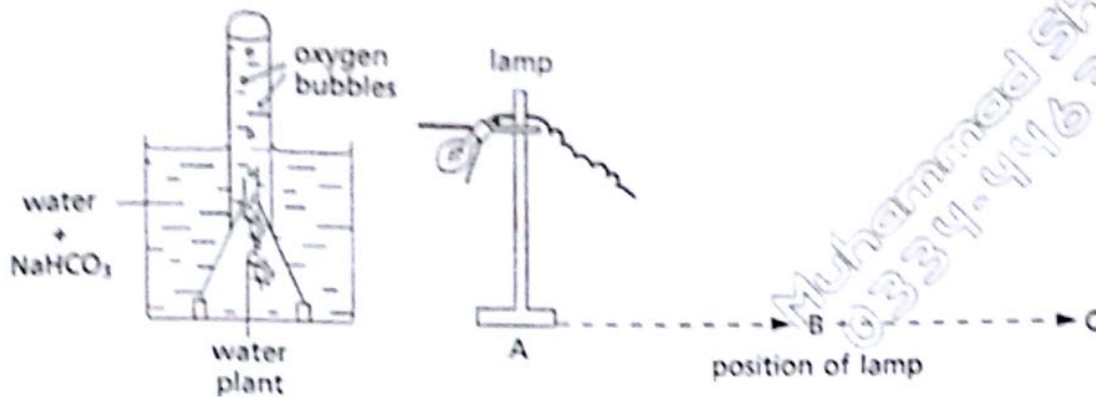
Investigation: To show the effect of varying the temperature on the rate of photosynthesis

Apparatus

- a large test-tube
- a bench lamp
- a length of stem from a water plant (e.g. *Elodea* or *Hydrilla*)
- a large beaker
- a timer
- a thermometer

Method

Set up the apparatus as shown below:



The temperature of the water bath is the only factor in this experiment that is altered. Lower the temperature of the water bath by adding ice, then leave the plant for 20-30 minutes to adjust to the conditions. Count the number of bubbles released by the cut stem over a period of 3 minutes and record the results.

Raise the temperature of the water bath above room temperature by adding warm water. Again, give the plant time to adjust (20-30 minutes). Check the thermometer regularly to make sure the temperature is maintained, adding warm water if necessary. Count the number of bubbles released over 3 minutes and record the results.

Results

The warmer the temperature (up to around 45°C) the more bubbles are released over the same period of time.

Conclusion

The warmer the temperature (up to about 45°C) the faster the rate of photosynthesis.

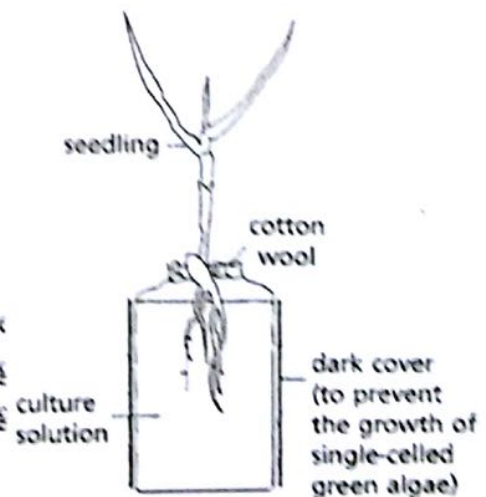
Investigation: To show the effects of a lack of nitrogen on the growth of a plant

Apparatus

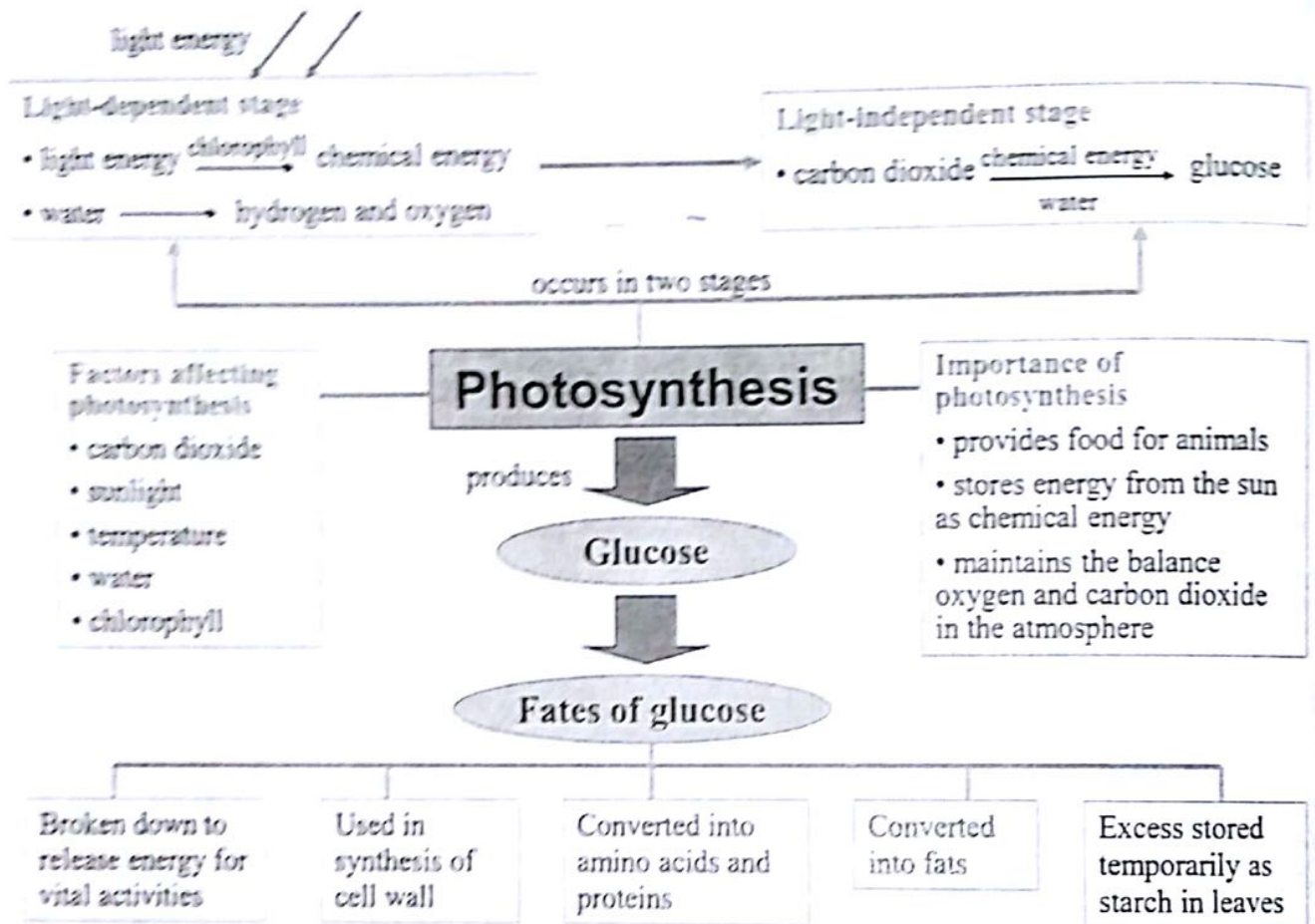
- two small cuttings or seedlings
- two containers
- cotton wool
- black paper or black polythene
- culture solutions

Method

Two seedlings (e.g. sorghum), or small cuttings with the same number of leaves are selected from a quick-growing plant and held in the top of two containers (A and B) using cotton wool, as shown.



Concept Map



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Syllabus Check List Plant Nutrition

After reading chapter are you able to:

- ☐ understand that photosynthesis is the fundamental process by which plants manufacture carbohydrates from raw materials
- ☐ investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls
- ☐ state the equation (in words or symbols) for photosynthesis
- ☐ investigate and state the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis (e.g. in submerged aquatic plants)
- ☐ understand the concept of limiting factors in photosynthesis
- ☐ describe the intake of carbon dioxide and water by plants
- ☐ understand that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent storage
- ☐ explain why most forms of life are completely dependent on photosynthesis
- ☐ identify and label the cuticle, cellular and tissue structure of a dicotyledonous leaf, as seen in cross-section under the microscope, and describe the significance of these features in terms of function, i.e.
 - distribution of chloroplasts – photosynthesis
 - stomata and mesophyll cells – gas exchange
 - vascular bundles – transport
- ☐ understand the effect of a lack of nitrate and magnesium ions on plant growth.

O-LEVEL

BIOLOGY

Topic 4:
Animal
Nutrition

NOTES BY

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Syllabus 2017 – 2019

Content

- 5.1 Nutrients
- 5.2 Diet
- 5.3 World food supplies
- 5.4 Human alimentary canal
- 5.5 Chemical digestion
- 5.6 Absorption and assimilation

NUTRITION

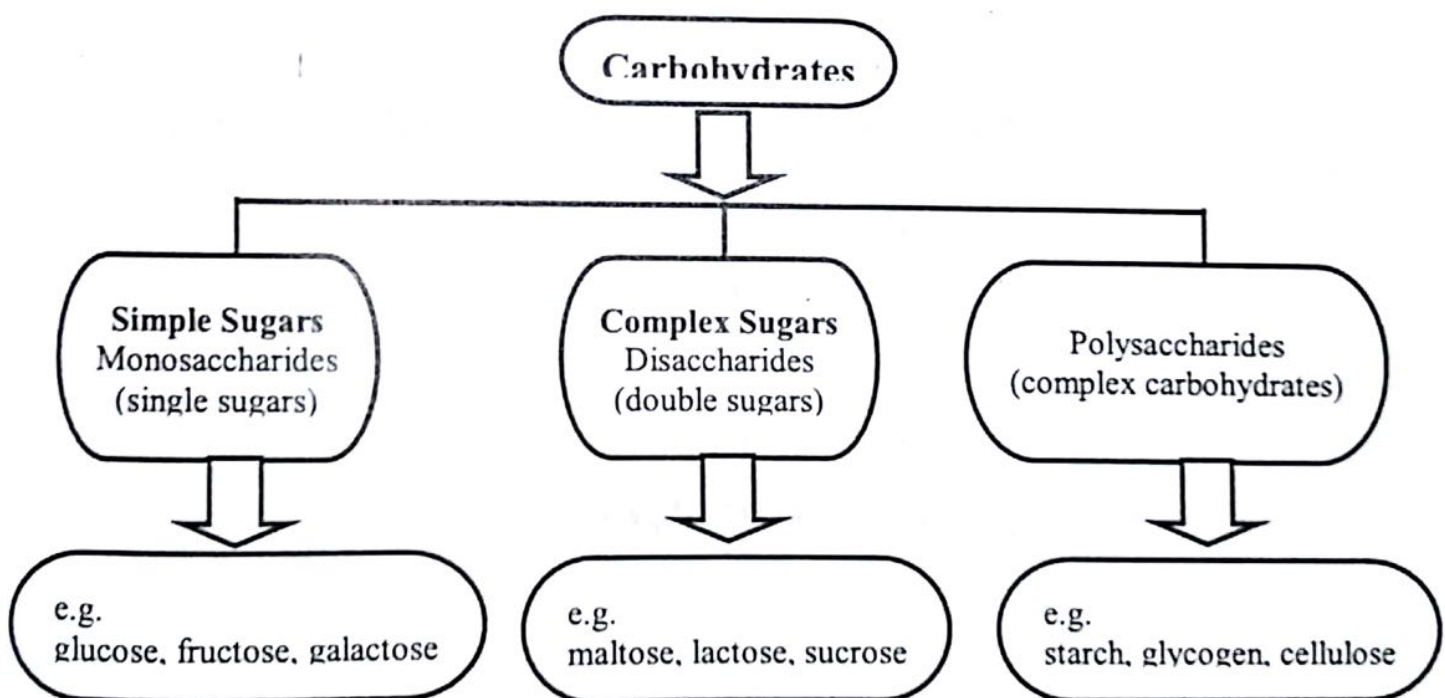
Every living organism depends on nutrition – the taking in of food, and the use of that food – for survival.

Carbohydrates, proteins and lipids are three of the most important classes of nutrients. These nutrients are needed by the body to perform vital activities, making new protoplasm and to prevent several deficiency diseases.

Carbohydrates

Carbohydrates are organic nutrients containing only the elements **carbon**, **hydrogen** and **oxygen**. The ratio of **hydrogen** atoms to **oxygen** atoms in a carbohydrate molecule is always **2:1** (as in water – hence carbohydrates). Carbohydrates are a source of energy. Carbohydrates with **large** molecules, such as starch and glycogen, are **insoluble**. (A starch 'solution' is really a starch 'suspension'.). Carbohydrates with larger molecules are made by the linking together of molecules of simple sugar (glucose). **Smaller** carbohydrate molecules are **soluble**, and occur as:

- (i) **complex** sugars, such as **maltose** and **sucrose** (table sugar), all with the formula $C_{12}H_{22}O_{11}$, or
- (ii) **simple** sugars, such as **glucose** or **fructose**, with the formula $C_6H_{12}O_6$.



Fats (or 'oils' if they are liquid at 20°C)

Like carbohydrates; fats are also organic chemicals containing only the elements **carbon**, **hydrogen** and **oxygen**. However, the ratio of hydrogen to oxygen in the fat molecule is very much higher than 2:1.

Fats are formed by the joining of a **glycerol** molecule with **fatty acid** molecules. They are all **insoluble in water**.

Fats are an efficient source and storage of energy. They are an important constituent of the protoplasm. Fats also work as an insulating material beneath the skin and on the other hand they serve to restrict the water loss from surface of skin.

Proteins

Proteins contain the elements **carbon**, **hydrogen** and **oxygen**, and in addition to these **nitrogen** is also their essential component. Often proteins contain other elements such as **sulphur** and **phosphorus**.

They are large, usually insoluble molecules which are built up from simple, soluble units known as **amino acid**.

Up to 100 amino acids linked together (by chemical bonds called peptide bonds) form a **polypeptide**. Polypeptides link together to form a protein (as shown in fig. 5.1).

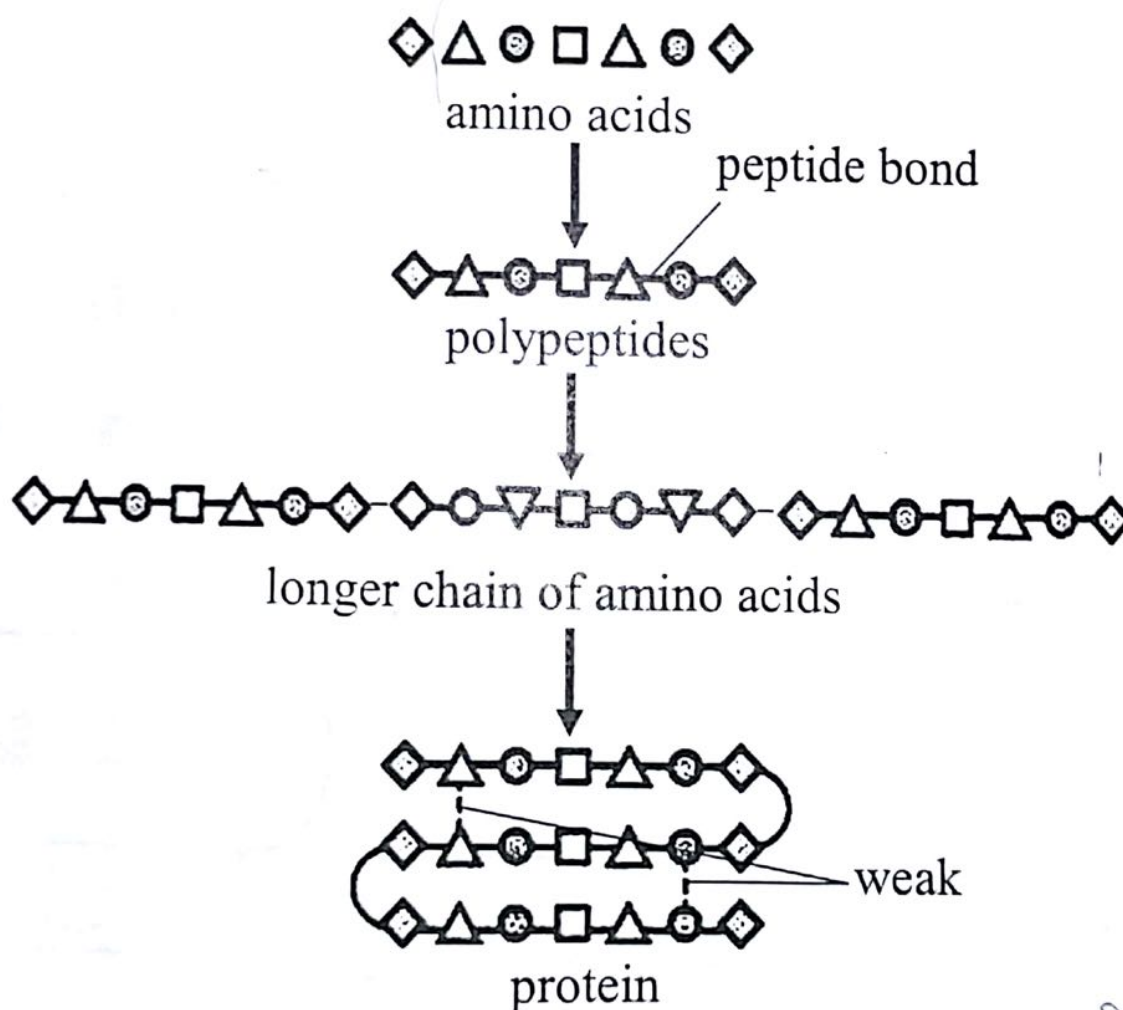


Figure 5.1 Protein synthesis from amino acids

Proteins are essential for synthesis of protoplasm, proteins, antibodies and hormones. They are also a source of energy.

Tests to show the presence of carbohydrates, fats and proteins

A. Carbohydrates

	Chemical ('reagent') used	How test is carried out	Result
Starch	Iodine Solution	Put a few drops on the substance to be tested.	Blue/black colour if starch is present (brown if starch is absent)
*Maltose and *Glucose	Benedict's Solution	Add a few drops to a solution of the substance to be tested and heat in a water bath at 90°C.	Red, orange, yellow or green if either of the sugars is present (blue if not).

*Benedict's solution does not distinguish between maltose (a complex sugar) and glucose (a simple sugar). When they react with Benedict's solution, both sugars work as chemicals known as 'reducing agents'. They belong to a group of sugars referred to as reducing sugars, all of which react in this way.

B. Fats (The ethanol emulsion test)

Reagent used	How test is carried out	Result
Ethanol	A dried* sample of the substance to be tested is mixed with ethanol. This mixture is poured into a test-tube of water.	The water turns cloudy if fat is present. The water remains clear if it is not.

*This test is more reliable if a dried sample is used. If it is not possible to dry the sample, the ethanol drained from it may already be cloudy, indicating the presence of a fat.

C. Proteins (The biuret test)

Reagent used	How test is carried out	Result
Burette Solution	Add equal volumes of biuret solution to the substance to be tested and gently shake	A purple colour indicates that protein is present (blue if it is absent).

Sources and functions of nutrients

The three classes of food described above are some of the **seven** important constituents (given below) of our diet.

1. Carbohydrates
2. Fats
3. Proteins
4. Vitamins
5. Mineral salts
6. Fibre (or roughage)
7. Water.

The main sources of these seven constituents, and why they are important in our diets are shown in the table 5.1.

Table 5.1 Nutrients along with source and importance

Constituent	Source	Importance
Carbohydrates		
Starch	potatoes beans and peas yams cassava cereals	Carbohydrate molecules contain energy which is released in cells as the molecules are broken down during respiration .
Sugars	honey sugar cane fruit	
Fats	fatty meat dairy foods egg yolk nuts avocadoes	Fat molecules contain more energy than carbohydrates and are stored in the skin and around the kidneys.
Proteins	meat peas and beans fish egg white peanuts	Proteins are used for growth and repair . Muscle is largely protein.
Vitamins		
C* (ascorbic acid)	citrus fruit (fresh) cabbage	For healthy gums and skin repair
D* (calciferol)	fish liver egg yolk the action of sun on the skin	For the uptake of calcium from the gut and for strong teeth and bone formation.
Mineral salts		
Calcium*	flour milk	For healthy bones and teeth , for muscle action and blood clotting.
Iron*	liver red meat spinach	For haemoglobin – the oxygen-carrying pigment in red blood cells.
Fibre	fruit vegetables nuts	Forms bulk in the intestines. This gives the muscles of peristalsis something to push against, preventing constipation. Fibre also reduces the amount of fat absorption and reduces the risk of bowel cancer.
Water	dinks all food	Water is the solvent for chemicals in the body. It is the medium for all chemical reactions. It is used to cool the body and makes up about 68% of body weight.

Deficiency diseases

If Vitamin C, Vitamin D, calcium or iron are lacking in a person's diet, then the individual will suffer from a **deficiency diseases**. The diseases are described below.

Diet lacking in Vitamin C

Symptoms include **bleeding gums** and wounds that do not heal properly. This disease is called **scurvy**. In extreme cases, anaemia (lack of blood) and heart failure may occur.

Diet lacking in Vitamin D

If children do not have enough Vitamin D in their diet, their growing **bones become soft**, causing bow-legs or knock-knees. This disease is called **rickets**. If older people lack Vitamin D in their diet, their bones are more likely to fracture.

Diet lacking in calcium

If a person lacks calcium in their diet, their **bones become brittle** and do not form properly. They suffer symptoms similar to those for lack of Vitamin D, and their **growth is stunted**.

Diet lacking in iron

A low level of iron in a diet leads to a **lack of haemoglobin**, which is necessary for carrying oxygen around the body. The person will not have enough energy. They will suffer from anaemia. In severe cases, iron deficiency leads to coma and death.

Energy requirements

Energy can be obtained from carbohydrates, fats and proteins. The amount of energy that can be obtained from food is measured in calories or joules. One gram of carbohydrate or protein can provide us with 16 or 17 kJ (kilojoules). A gram of fat can give 37 kJ. We need to obtain about 12 000 kJ of energy each day from our food. Table 5.2 shows how this figure is obtained.

Table 5.2 Energy Requirements in Kilojoule

8 hours asleep	2 400
8 hours awake; relatively inactive physically	3 000
8 hours physically active	6 600
Total	12 000

The 2400 kJ used during 8 hours' sleep represents the energy needed for basal metabolism, which If the diet includes more food than is needed to supply the energy demands of the body, the surplus food is stored either as glycogen in the liver or as fat below the skin and in the abdomen.

However, the figure will vary greatly according to our age, **occupation and activity** (Figure 7.2). It is fairly obvious that a person who does hard manual work, such as digging, will use more energy than someone who sits in an office. Similarly, someone who takes part in a lot of sport will need more energy input than someone who doesn't do much physical exercise.

Nutrients requirement also depends upon **gender**. Females tend to have lower energy requirements than males. Two reasons for this are that females have, on average, a lower body mass than males, which has a lower demand on energy intake, and there are also different physical demands made on boys and girls. However, an active female may well have a higher energy requirement than an inactive male of the same age.

As children grow, the energy requirement increases because of the energy demands of the growth process and the extra energy associated with maintaining their body temperature. However, metabolism, and therefore energy demands, tends to slow down with age once we become adults due to a progressive loss of muscle tissue.

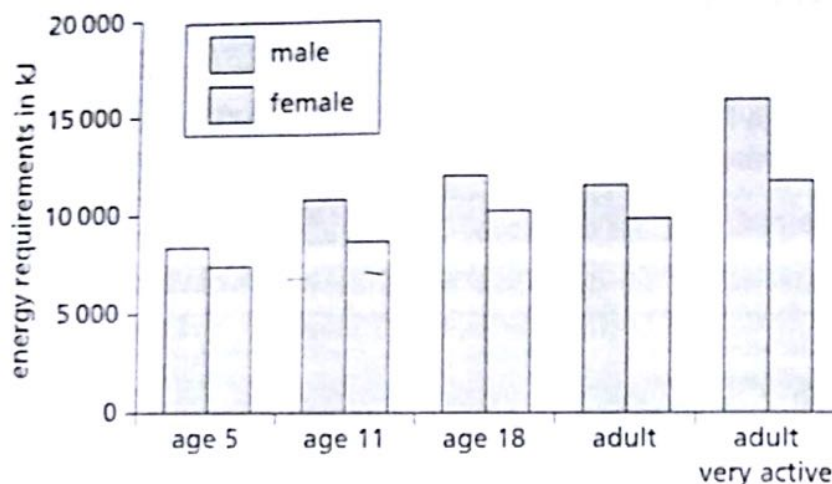


Figure 5.2 Changing Energy Requirement with age and activity

A balanced diet

A balanced diet must contain enough carbohydrates and fats to meet our energy needs. It must also contain enough protein of the right kind to provide the essential amino acids to make new cells and tissues for growth or repair. The diet must also contain vitamins and mineral salts, plant fibre and water. A diet which has the correct amount of each constituent of food is called a **balanced diet**. A balanced diet is different for each person and depends on lifestyle, age and gender.

Type of person	Special requirements	Reason
Child	protein carbohydrate calcium	for growth for energy for bones and teeth
Active adult	carbohydrate protein	for energy to build muscles
Pregnant woman	iron salts calcium protein	for blood for baby's bones for making baby's cells

If a person's diet is unstable for healthy growth then there may be two main reasons for that:

1. Malnutrition (Incorrect balance of nutrients)
2. Starvation (Insufficient quality)

Malnutrition

Malnutrition is often taken to mean simply **not getting enough food**, but it has a much wider meaning than this, including **getting too much food or the wrong sort of food**. Constipation, heart disease and obesity are effects of malnutrition.

Many of the processed foods contain too little fibre. White bread, for example, has had the fibre (bran) removed. A lack of fibre can result in **constipation**. Unprocessed foods, such as unskinned potatoes, vegetables and fruit, contain plenty of fibre. Food rich in fibre is usually bulky and makes you feel 'full up' so that you are unlikely to overeat. Fibre enables the process

of peristalsis to move food through the gut more efficiently and may also protect the intestines from cancer and other disorders. As explained earlier, fibre helps prevent constipation.

If you take in more food than your body needs for energy, growth and replacement, the excess is converted to fat and stored in fat deposits under the skin or in the abdomen. **Obese** people are more likely to suffer from high blood pressure, coronary heart disease and diabetes. Coronary heart disease can occur when the diet contains too much fat. Deposits of a fatty substance build up in the arteries, reducing the diameter of these blood vessels, including the coronary artery. Blood clots are then more likely to form. Blood supply to the heart can be reduced resulting in angina (chest pains when exercising or climbing stairs, for example) and eventually a coronary heart attack.

Having extra weight to carry also makes you reluctant to take exercise. Why some people should be prone to obesity is unclear. There may be a genetic predisposition, in which the brain centre that responds to food intake may not signal when sufficient food has been taken in; in some cases it may be the outcome of an infectious disease. Whatever the cause, the remedy is to reduce food intake to a level that matches but does not exceed the body's needs. Taking exercise helps, but it takes a great deal of exercise to 'burn off' even a small amount of surplus fat.

Starvation

If the total intake of food is not sufficient to meet the body's need for energy, the body tissues themselves are broken down to provide the energy to stay alive. This leads to loss of weight, muscle wastage, weakness and ultimately **starvation**. Extreme slimming diets, such as those that avoid carbohydrate foods, can result in the disease anorexia nervosa. Starvation often leads to **famine** (a lack of adequate amount of food to support the population). Famine is usually caused by:

- overpopulation
- unequal distribution of food
- flooding
- earthquake
- drought
- poverty
- war/political instability

Developing countries have increasing population growth and the countries are unable to produce enough food for the people. In some countries due to economic interests crops are grown to be exported to other countries instead of feeding their own people which is a leading cause of unequal distribution of food. Further cost of transportation of food from where it is highly produced to where it is lacking is very high. Natural disasters like earthquakes and floods destroy crops on a large scale depriving the local population from food stuff and worsen the problem of famine. Climate changes leading to longer gaps in rainfall leads to drought. Water is essential for plant growth and for good health maintenance of animals. Lesser availability of water results in reduced crop yield.

ANIMAL NUTRITION

Based on phenomenon of obtaining food living organisms can be classified into autotrophs and heterotroph. Autotrophs (like plants) are organisms who can manufacture their own food (so called as **autotrophic** in nutritional mood). On the other hand heterotrophs ('hetero' = other, 'trophic' = feeding) (like animals) cannot manufacture their own food (so called as **heterotrophic** in nutritional mood), so they obtain their food requirements 'second-hand' either by eating plants, or by eating other animals which have eaten plants.

Nutrition is the intake of food and the processes that convert food substances into living matter. Nutrition comprises of the following:

FEEDING: the intake of food into the body.

DIGESTION: the process whereby large food molecules are broken down into soluble and diffusible molecules that can be absorbed into the body cells.

ABSORPTION: the process whereby digested food materials are taken into the body cells.

ASSIMILATION: the process whereby some of the absorbed food materials are converted into new protoplasm or used to provide energy

Overall digestion is of two types including physical and chemical digestion.

Physical digestion comprises of mechanical breakdown of food into small particles so that the surface area to volume ratio could be increased of the ingested food and that digestive enzymes can act on the food more efficiently. Physical digestion occurs in the **mouth**, when you chew food using your teeth and in the **stomach**, where churning of the stomach walls breaks up the food particles and mixes them with digestive enzymes.

Chemical digestion is the enzymatic hydrolysis of large food molecules into small soluble molecules which can be absorbed and this is achieved by the **digestive enzymes** found in the mouth, stomach, duodenum and ileum.

The need for chemical digestion

Most foods contain insoluble starch, protein and fat. These **large, insoluble molecules** cannot be absorbed into the blood stream, so they need to be broken down into **small, soluble and absorbable** (diffusible) ones. **Glucose, amino acids, fatty acids and glycerol** are the smallest forms of their 'parent' molecules.

The functions of the main regions of the alimentary canal

Mouth

This is the opening through which food is ingested into the **buccal cavity** (or mouth cavity). The buccal cavity processes the food as follows:

1. **Teeth** mechanically digest the food.
2. **Salivary glands** secrete a solution (**saliva**) of the enzyme **amylase** to digest starch, and the protein **mucin**. Mucin is sticky, so it binds the food together and lubricates it.
3. The **tongue** rolls the food into balls or boli (singular: 'bolus') and pushes them to the back of the buccal (mouth) cavity for swallowing.

Action of salivary amylase:**Starch → maltose**

The pH of saliva is neutral (around pH 7). Salivary amylase is active at this pH.

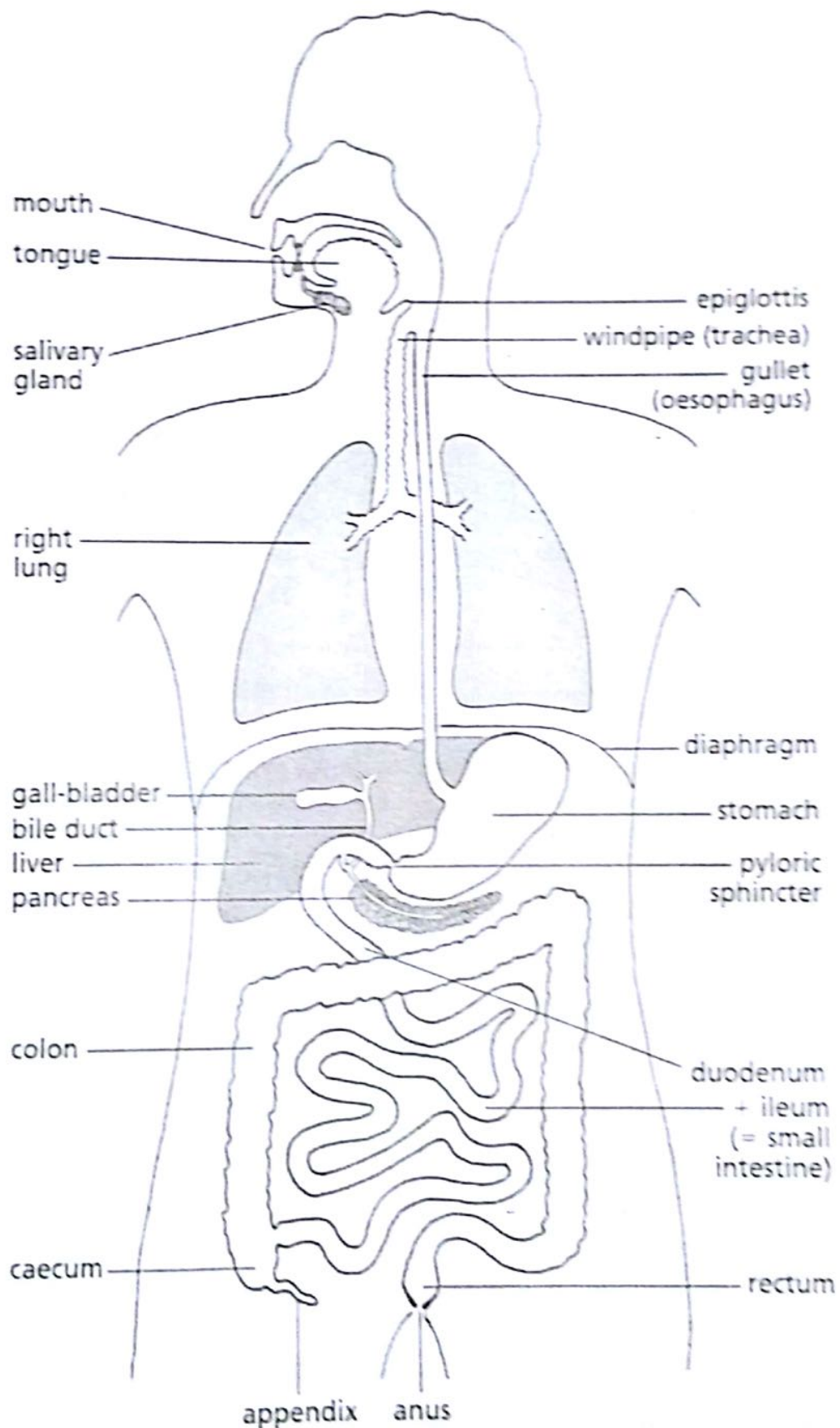
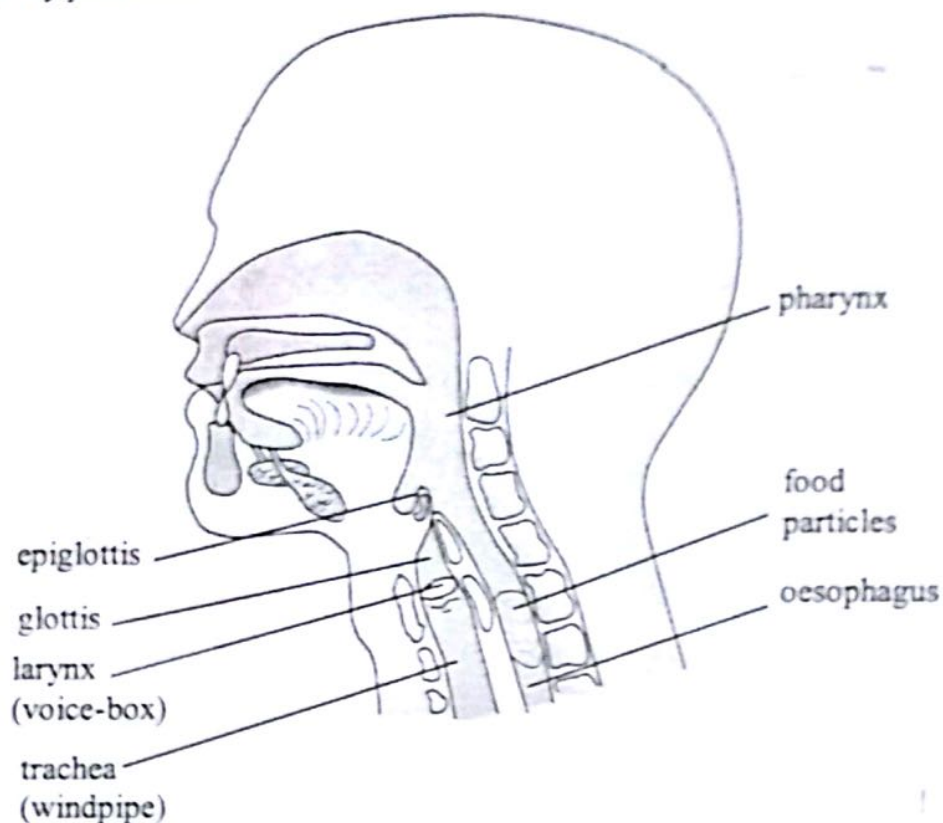


Figure 6.1 The Human Alimentary Canal

Food entry to oesophagus

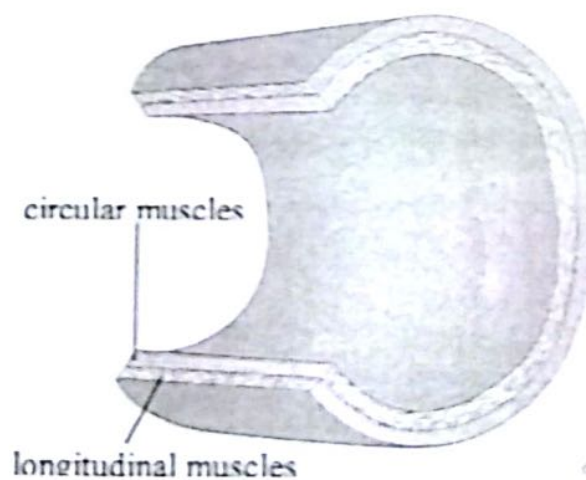
During swallowing, the larynx is raised and the glottis is covered by the epiglottis. This prevents food particles from entering the trachea. Food particles then pass down the oesophagus by peristalsis.



Oesophagus

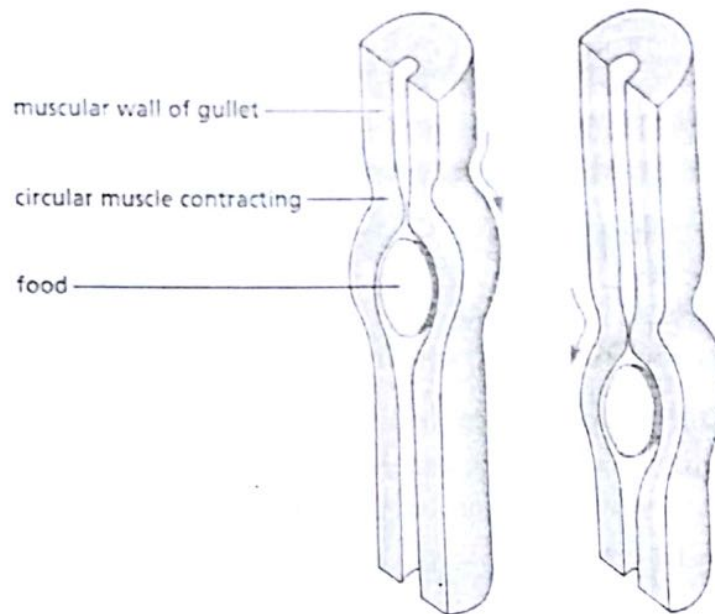
The oesophagus is a muscular tube connecting the mouth cavity and the stomach. The wall of the oesophagus is made up of two layers of muscles. The two layers of muscles are:

- the longitudinal muscles on the outside of the gut; and
- the circular muscles on the inside of the gut.



These muscles are present along the gut from the oesophagus to the rectum. The two layers of muscles cause rhythmic, wave-like contractions of the gut walls. Such movements are known as **peristalsis**.

The circular muscles constrict the **lumen** whereas the longitudinal muscles shorten the lumen. The circular and longitudinal muscles are **antagonistic muscles**. When one set of muscles contracts, the other set relaxes.



Peristalsis:

- enables food to be mixed with the digestive juices; and
- moves the food along the gut.

As result of peristaltic movement food in form of bolus enters the stomach. Remember that no digestion takes place in oesophagus.

Stomach

The presence of food in the stomach stimulates the gastric glands to secrete **gastric juice** into the stomach cavity. Peristalsis in the stomach wall churns and breaks up the food for four hours. Peristalsis also mixes the food well with gastric juice.

Gastric juice which contains:

- (i) The enzyme **protease** for starting the digestion of **proteins**, changing them to polypeptides.
- (ii) The enzyme **renin** to clot protein in milk (in children only).
- (iii) **The dilute Hydrochloric acid:**
 - a) stops the action of salivary amylase by denaturing it;
 - b) changes the inactive forms of the enzymes, pepsinogen and prorennin, in the gastric juice, to the active forms, pepsin and rennin respectively;
 - c) provides a slightly acidic medium suitable for the action of the gastric enzymes (protease).
 - d) kills certain potentially harmful microorganisms in food.

Action of Pepsin: proteins → polypeptides

Action of Rennin: caseinogen → casein

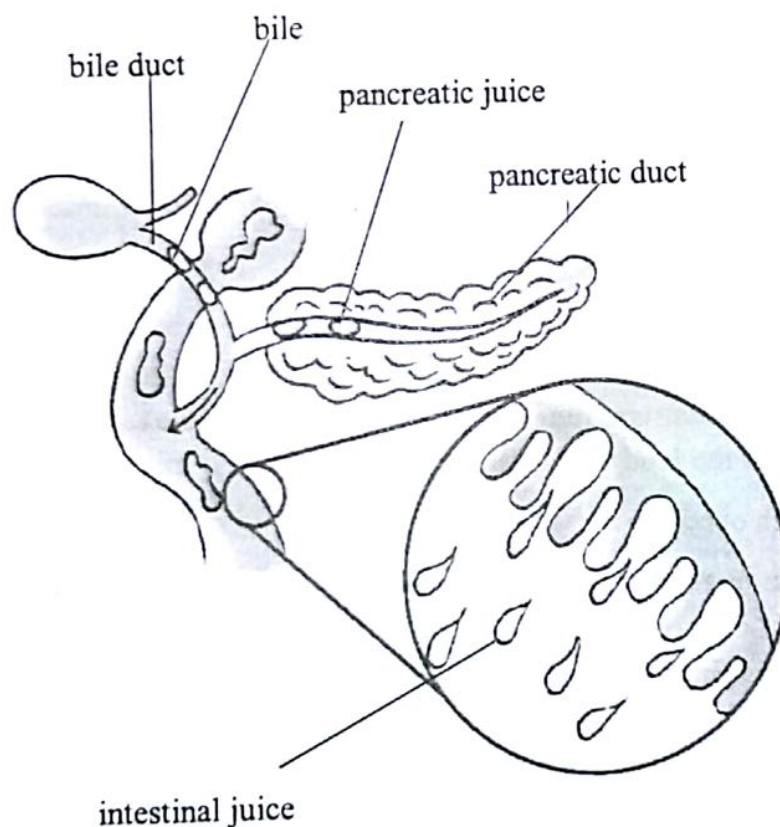
After treatment in the stomach, the food is in the form of soup-like '**chyme**'. It passes through a ring of muscle called the **pylorus** or **pyloric sphincter**, which relaxes to allow the food to enter the small intestine. Small intestine is around 6m long. It consists U-shaped **duodenum** (first part of small intestine), **jejunum** and the much coiled **ileum**. Three types of digestion occurs in small intestine:

1. **Carbohydrate** digestion (continues from the mouth)
2. **Protein** digestion (continues from the stomach)
3. **Fat** digestion (1st time digestion!)

Duodenum

The duodenum is a tube about 30 cm long which:

- (i) Receives **bile** via the bile duct, from the liver.
- (ii) Receives **pancreatic juice** from the pancreas, through the pancreatic duct.
- (iii) Releases a digestive juice from its walls, this **intestinal juice** contains protease and the enzyme **lipase**, for fat digestion.



Pancreas

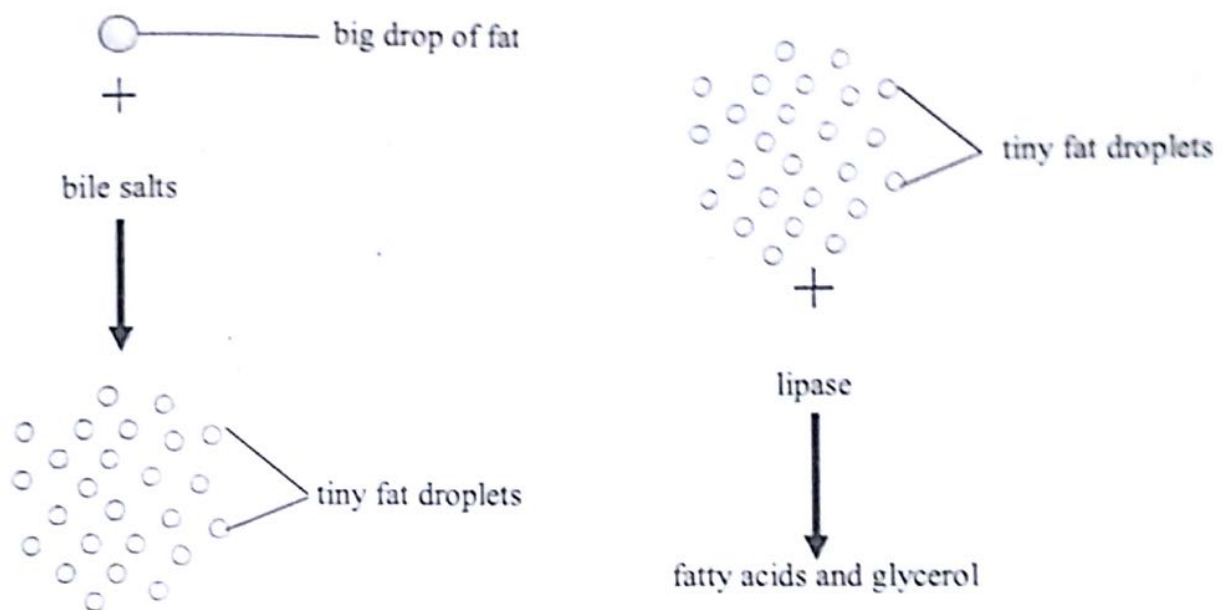
The pancreas lies between the stomach and the duodenum. It secretes **pancreatic juice**, which it passes to the duodenum to help in digestion. Pancreatic juice contains the following enzymes:

- (i) Amylase for digesting starch (starch $\rightarrow$ maltose)
- (ii) Lipase for digesting fat (fats $\rightarrow$ fatty acids + glycerol)
- (iii) Protease for digesting protein (protein $\rightarrow$ polypeptides)

The amylase from the pancreas completes the job started by the amylase in the buccal cavity, changing any remaining **starch** to **maltose** sugar.

The protease changes any remaining **proteins** to **polypeptides**. Unlike the acid stomach contents where protease starts the digestion of protein, the contents of the duodenum are very slightly alkaline. The alkaline bile from the liver neutralizes the stomach's hydrochloric acid.

Bile breaks up, or '*emulsifies*', fats into small droplets. (Note that this is just a physical break-up, but no chemical digestion of fat molecules has occurred) which greatly increases their surface area. Lipase can then work on them far more quickly, changing **fats** into **fatty acids** and **glycerol**.



Bile salts emulsify fats into tiny fat droplets. Bile salts emulsify fats into tiny fat droplets.

Liver

The liver is the largest internal organ and is called the 'chemical factory' of the body. Like the pancreas, it is not technically part of the alimentary canal, but its function of producing **bile** is closely associated with digestion. Bile is a greenish-coloured fluid. It is **alkaline** due to the salts it contains, and is stored in the **gall bladder** before it is passed into the duodenum. Its functions are:

- (i) to neutralise acidic chyme from the stomach
- (ii) to emulsify fat

Large food molecules are almost ready for absorption. But first, enzymes in the intestinal juice change maltose into **glucose** by the enzyme maltase, and polypeptide into **amino acids**.

Ileum

The ileum is the region where the **absorption** of digested food takes place. To increase its efficiency, its **surface area is increased** in the following ways:

- (i) it is about seven metres long (in a person)
- (ii) its walls are folded ('pleated') longitudinally
- (iii) its walls have millions of microscopic finger-like projections called villi.

Colon

The colon absorbs water, salts and vitamins. For more effective absorption, its walls are folded (transversely, or cross-ways, this time) to increase its surface area. Infections of the colon lead to diarrhoea.

Food is moved steadily along the duodenum, ileum and colon by **peristalsis** (which also occurs in the oesophagus). The indigestible fibre forms the bulk against which the muscles of the intestines can push.

Rectum

The rectum is a muscular storage chamber where the undigested food (**faeces**) is held and moulded before being pushed out through the anus during **egestion**.

Anus

The anus is the exit to the alimentary canal. It is closed by a ring of muscle (the anal sphincter) which is relaxed during egestion (or 'defaecation').

Summary of chemical digestion in the alimentary canal

Where digested	Name of food	Enzyme involved	Product
buccal cavity	Starch (Carbohydrates)	amylase	maltose
duodenum	Starch	amylase (from pancreas)	maltose
duodenum	Maltose	maltase	glucose
stomach	Proteins	protease	polypeptides
duodenum	Proteins	protease (from pancreas)	polypeptides
duodenum	Polypeptides	protease	amino acids
duodenum	Fats	lipase (from pancreas and intestinal juice)	fatty acids and glycerol

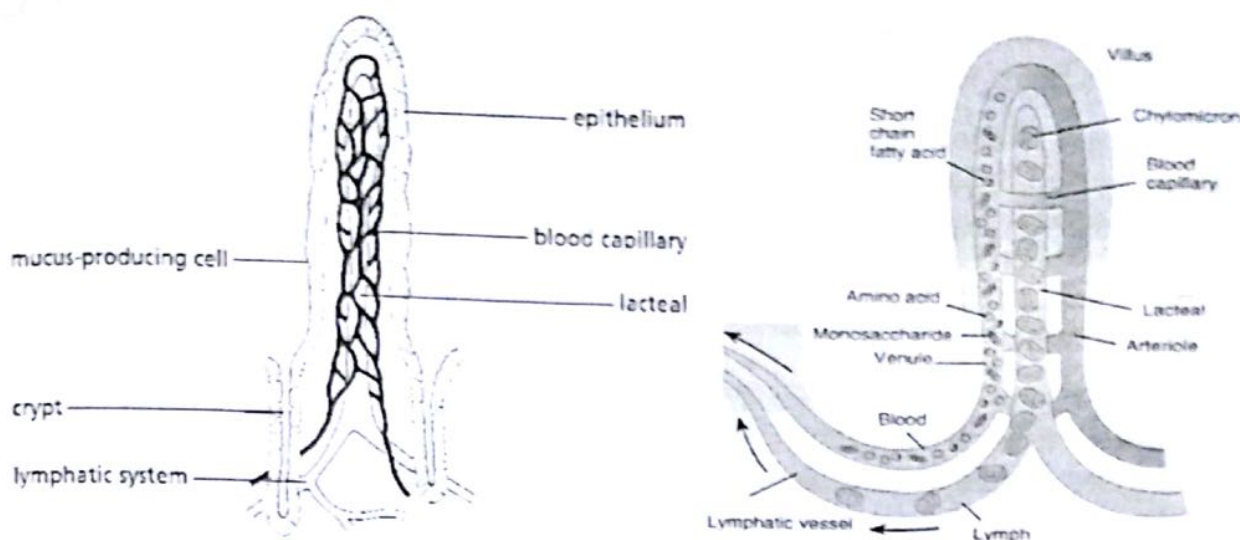
The absorption and assimilation of food

Villi

The villi of the ileum are specially adapted for the process of food absorption. They:

- are extremely **numerous** – increasing the internal surface area of the ileum
- are very **thin-walled** (one cell thick)
- contain **blood capillaries** just beneath their walls
- contain special structures (**lacteals**) for absorbing fatty acids and glycerol
- are able to **move** to bring themselves into close contact with food.

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A Villus

Amino acids and glucose, after absorption by the blood capillaries in the villi, are carried **directly** to the **liver** for the first stage of their treatment in the body. They are carried by a blood vessel called the **hepatic portal vein**.

Fats, after entering the lacteals in the villi, travel in the LYMPHATIC SYSTEM. They by-pass the liver and enter the circulatory system at a vein in the neck.

Assimilation

The main food substances, absorbed as small soluble molecules, must now be built up into the larger molecules needed by the body.

Glucose (and any other simple sugars which can be absorbed by the villi) may be used as it is, as a substrate for **RESPIRATION** to release energy. However, after a meal, there is more glucose available than is needed immediately. It needs to be **stored**. For this purpose, it is built up into a large insoluble molecule called **glycogen** (similar to starch). It is stored in the cells of the **liver** and **muscles**. The uptake of glucose and its conversion to glycogen is controlled by the hormone **insulin**, secreted by the pancreas.

Amino acids are used in cells for building up **proteins** as the cells **grow**, and also for making special proteins such as **enzymes**. Amino acids and proteins are **never stored**. Any **excess** amino acids are broken down in the **liver** by a process called **DEAMINATION**.

Two separate molecules are produced as a result of deamination:

- (i) A **carbohydrate** which can be changed to glycogen and stored.
- (ii) **UREA**, a **nitrogenous** waste product (i.e. one which contains nitrogen), which passes in the blood from the liver to the kidneys for excretion in **urine**.

The role of the liver in glucose and amino acid metabolism

The liver is involved in the **regulation of blood glucose levels**. It is involved in changing glucose to glycogen, and storing glycogen when blood glucose levels are high. It also re-

Topic 3
converts glycogen to glucose, and releases the glucose into the blood when blood glucose levels are low. The liver also removes excess amino acids from the blood by deamination.

Another major function of the liver is DETOXIFICATION, the removal and breakdown of poisons (**toxins**) from the blood. One of these toxins is **alcohol**. Although the liver is able to remove small quantities of alcohol, even on a regular basis, frequent high levels of alcohol in the blood can eventually lead to **liver disease** ('cirrhosis').

Fat metabolism

The liver does not play a major part in fat metabolism. Once in the blood, **fatty acids** and **glycerol** re-combine to form tiny fat droplets. Fats at body temperature are in liquid form, so the word LIPID is used to cover both fats and oils.

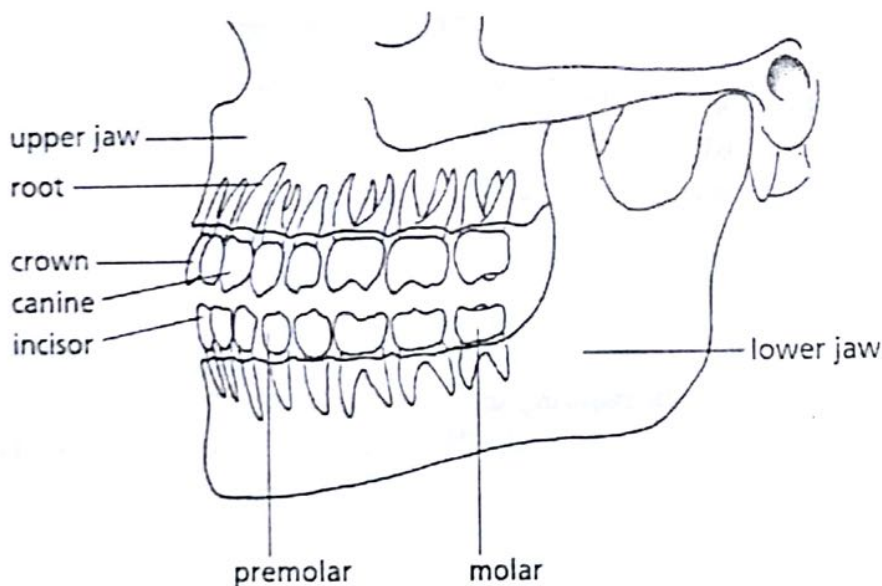
Lipids are stored in special storage cells in the skin ('adipose' tissue), and around the kidneys.

Fat is a good insulator, or protector, against **physical damage** and **low temperature**, and is a very efficient **energy store**. But fat is also heavy, and can lead to obesity.

Teeth and the part they play in mechanical digestion

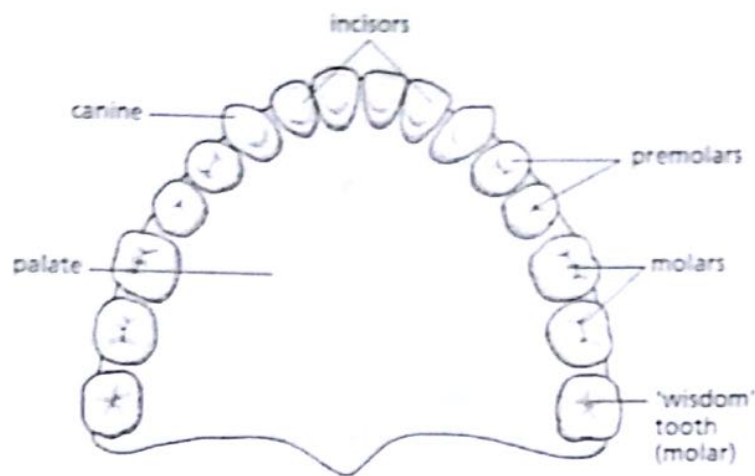
A person has **two** sets of teeth in their lifetime. The first set (called MILK TEETH) last for around 10–12 years, then they are pushed out by the **permanent** teeth. There is only one permanent set of **molar** teeth – there are no 'milk molars'.

In the permanent set, there are four types of tooth. The number of each type of tooth, shown below, is expressed as 'per quarter-jaw'. A quarter-jaw is one half of the top jaw, or one half of the bottom jaw.



Human Jaw and Teeth

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Human Upper Jaw

Incisors

There are **two** incisors in the front of each quarter-jaw. They are sharp, spade-like teeth for **biting and cutting** food. They are single-rooted.

Canines

There is **one** canine per quarter-jaw. They are shaped like a cone, are sharp and used for **biting and cutting** food. They are single-rooted.

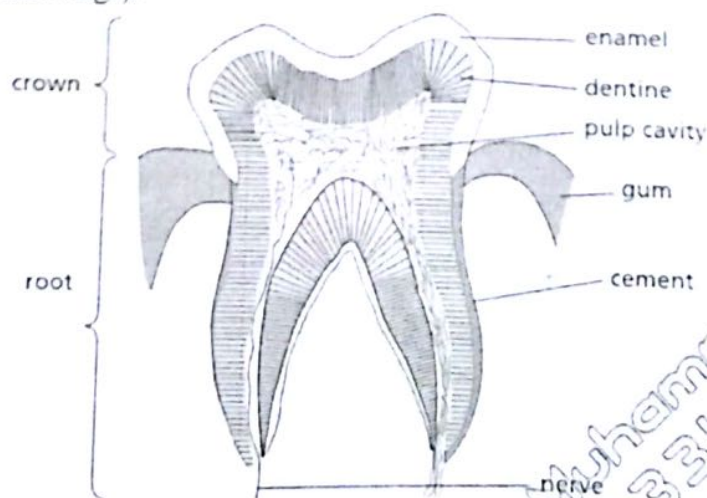
Pre-molars

There are **two** pre-molars per quarter-jaw. The surface of each tooth has two projections ('cusps') which are used for **crushing and grinding** food. They are double-rooted teeth.

Molars

There are **three** molars per quarter-jaw. The tooth surface is square with four cusps, or point, for **crushing and grinding** food. They are double-rooted teeth. The third molars – wisdom teeth – do not usually appear until a person is at least 17 years old.

Therefore, the function of teeth in mechanical digestion is to **bite, cut, crush and grind** food (also loosely called 'chewing').



Section through Molar Teeth

The importance of proper tooth care

If teeth are not properly cared for, they may suffer from **dental caries** (or **dental decay**).

Decay process

1. Food (particularly food containing sugar) becomes stuck between the teeth.
2. **Bacteria** settle in the sugary deposits, using them for their own metabolism.
3. The bacteria excrete **acids** which dissolve the outer non-living covering (**enamel**) of the tooth.
4. A **cavity** develops, in which more sugary deposits collect. More bacteria settle, excreting more acids. The size of the cavity increases.
5. Eventually, the decay reaches the **living** parts of the tooth. The first area affected is the dentine, where there are nerve endings. The tooth begins to ache. Then the decay reaches the pulp cavity – leading to an abscess (a painful swelling filled with pus).

Tartar

If you do not clean your teeth, a mixture of food, saliva, cheek cells and bacteria collects at the neck of the tooth (where it enters the gum). This deposit is called **tartar**. The acids released by the bacteria damage the enamel of the tooth in that region, and cause **gum disease**.

Plaque

If not removed, tartar hardens to form **plaque**. Plaque forms a solid barrier, so bacteria trapped between it and the tooth can decay the tooth without interference.

How to care for teeth

- (i) Do not eat sweet or starchy foods before going to bed. Saliva flow stops when we are asleep and prevents the sugar from being washed away. It is better to eat a raw, crunchy food, such as a carrot.
- (ii) Brush teeth last thing at night, and first thing in the morning. Careful brushing removes plaque.
- (iii) Use dental floss regularly to remove fragments of food from between the teeth.
- (iv) Use a toothpaste which:
 - contains fluoride to strengthen the tooth enamel
 - contains a bactericide (to kill bacteria)
 - is alkaline, to neutralise acids released by the bacteria
- (v) Visit the dentist regularly for an examination, and have treatment if required.

Syllabus Check List Animal Nutrition

After reading chapter are you able to:

- ☐ list the chemical elements that make up:
 - carbohydrates
 - fats
 - proteins
- ☐ describe tests for:
 - starch (iodine in potassium iodide solution)
 - reducing sugars (Benedict's solution)
 - protein (biuret test)
 - fats (ethanol emulsion test)
- ☐ list the principal sources of, and describe the dietary importance of carbohydrates, fats, proteins, vitamins (C and D only), mineral salts (calcium and iron only), fibre (roughage) and water
- ☐ name the diseases and describe the symptoms resulting from deficiencies of vitamin C (scurvy), vitamin D (rickets), calcium (rickets) and iron (anaemia)
- ☐ understand the concept of a balanced diet
- ☐ explain why diet, especially energy intake, should be related to age, sex and activity of an individual
- ☐ state the effects of malnutrition in relation to starvation, heart disease, constipation and obesity
- ☐ discuss the problems that contribute to famine (unequal distribution of food, drought and flooding, increasing population)
- ☐ identify the main regions of the alimentary canal and the associated organs: mouth (buccal) cavity, salivary glands, oesophagus, stomach, duodenum, pancreas, gall bladder, liver, ileum, colon, rectum and anus
- ☐ describe the main functions of these parts in relation to ingestion, digestion, absorption, assimilation and egestion of food, as appropriate
- ☐ identify the different types of human teeth and describe their structure and functions
- ☐ state the causes of dental decay and describe the proper care of teeth
- ☐ describe peristalsis
- ☐ explain why most foods must be digested
- ☐ describe:
 - digestion in the alimentary canal
 - the functions of a typical amylase, protease and lipase, listing the substrates and end-products
- ☐ describe the structure of a villus, including the roles of capillaries and lacteals
- ☐ describe the significance of villi in increasing the internal surface area
- ☐ state the function of the hepatic portal vein as the route taken by most of the food absorbed from the small intestine

☐ state:

- that large molecules are synthesised from smaller basic units:
 - glycogen from glucose
 - proteins from amino acids
 - lipids (fats and oils) from glycerol and fatty acids
- the role of the liver in the metabolism of glucose and amino acids
- the role of fat as a storage substance
- that the formation of urea and the breakdown of alcohol occur in the liver.

For Books Order
0321-1100570

O-LEVEL BIOLOGY

Topic 6: Transport in Flowering Plants

NOTES BY

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Syllabus 2017 – 2019

Content

- 6.1 Water and ion uptake
- 6.2 Transpiration and translocation

TRANSPORT IN FLOWERING PLANTS

The transport system of flowering plants has to provide:

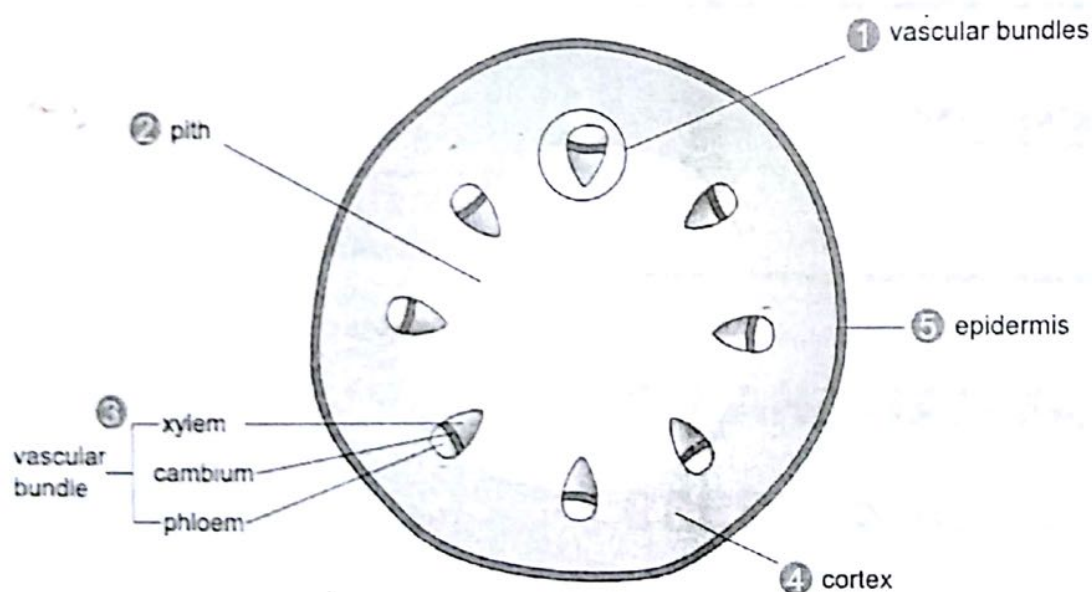
- A way of carrying **water and ions** from the roots to the leaves.
- A way of carrying **sugars and amino acids** from the leaves to other parts of the plant while it is photosynthesizing.
- If necessary, a way of carrying **sugars and amino acids** from storage organs to the leaves when it is not photosynthesizing.

Vascular bundles contain **xylem** for carrying water and ions and **phloem** for carrying sugar and amino acids.

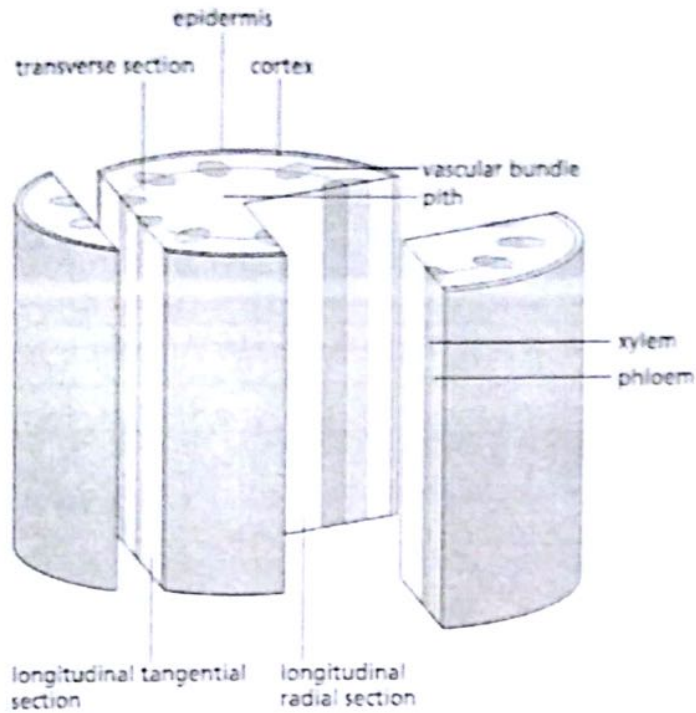
Xylem	Phloem
Consists of dead cells	Consists of living cells
-Transports water and mineral salts -Provide mechanical support to the plant	Transports sugar and amino acids
Transport is unidirectional	Transport – directional, upwards and downwards
Substances are transported by passive transport - osmosis, root pressure, capillary action, transpiration pull	Substances are transported by active transport, diffusion

The movement of sugar and amino acids around a plant is called **translocation**.

The positions occupied by xylem and phloem in the vascular bundles of roots, stems and leaves in a typical dicotyledonous plant are shown below.

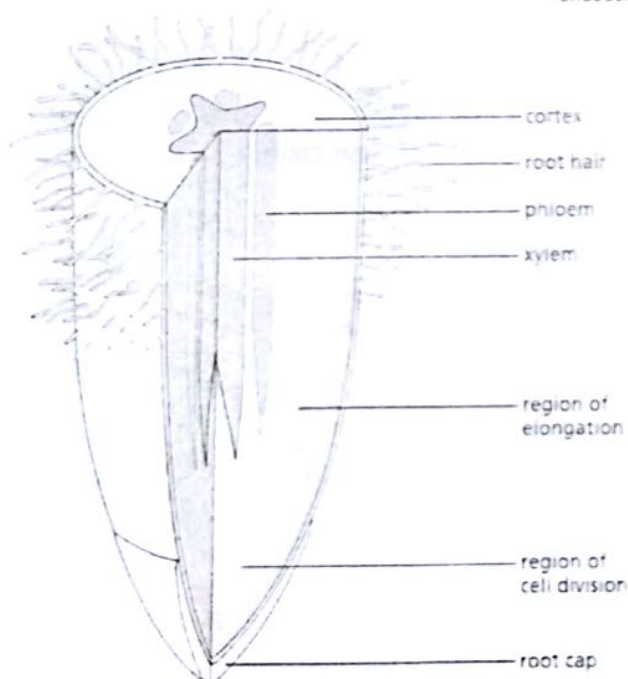
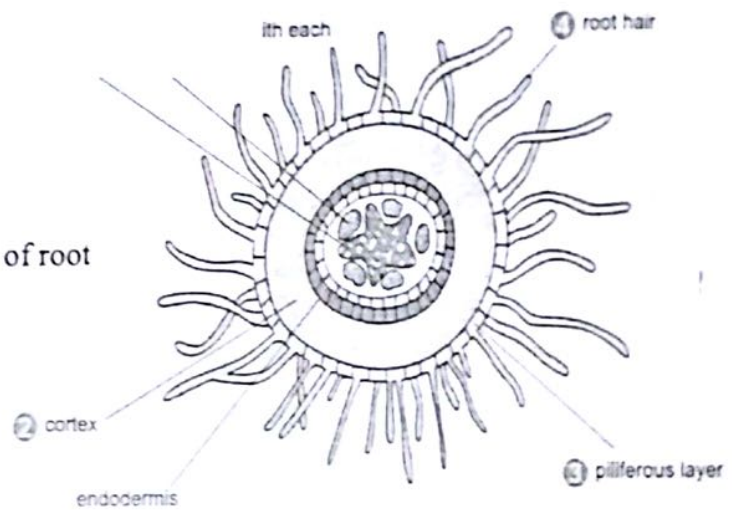


Cross section of stem



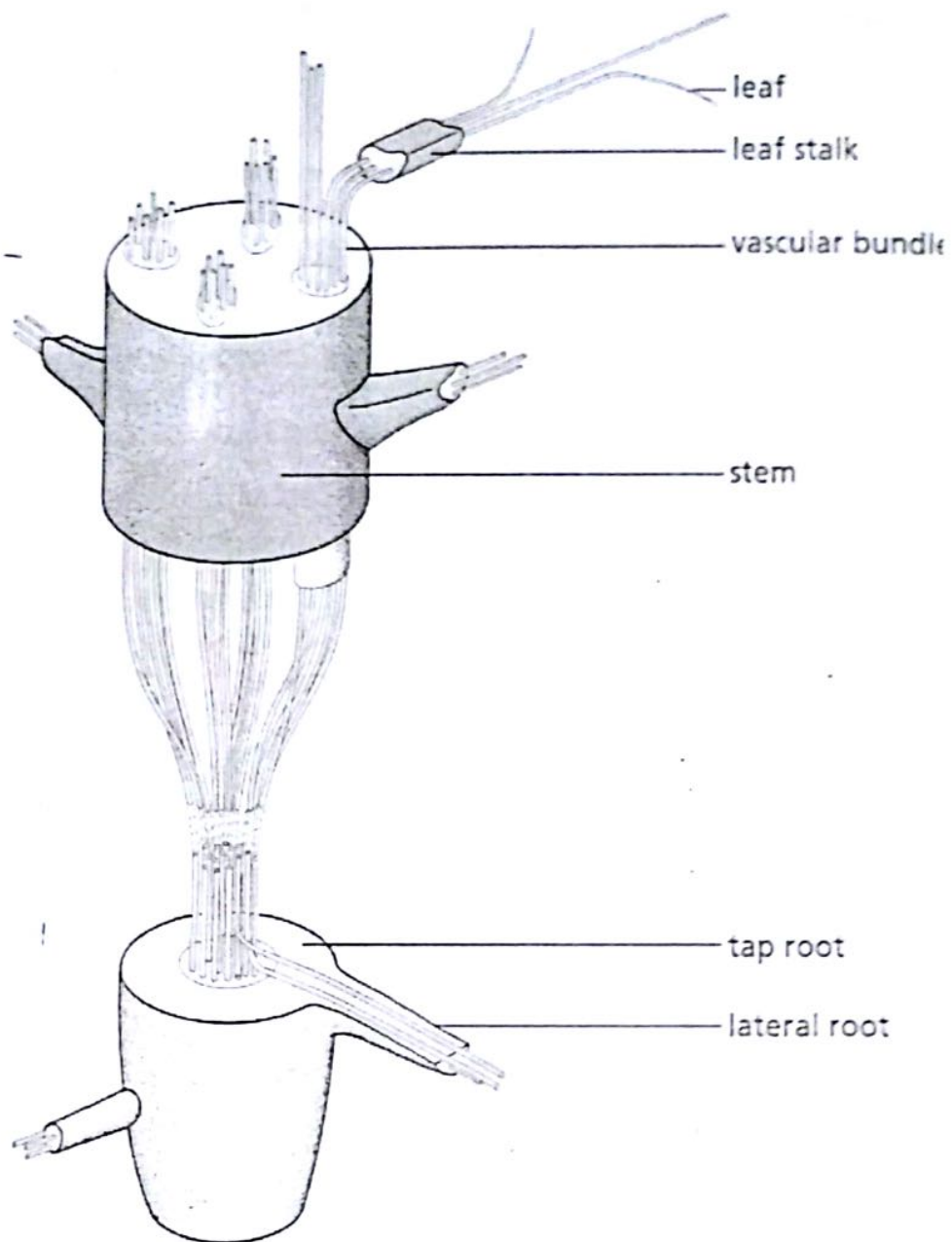
Sections of stem

Cross section of root

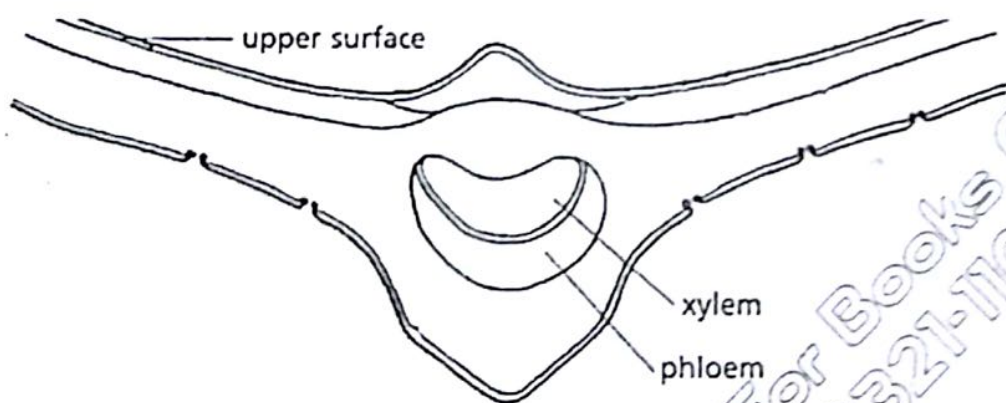


Root Structure

Muhammed Shahid
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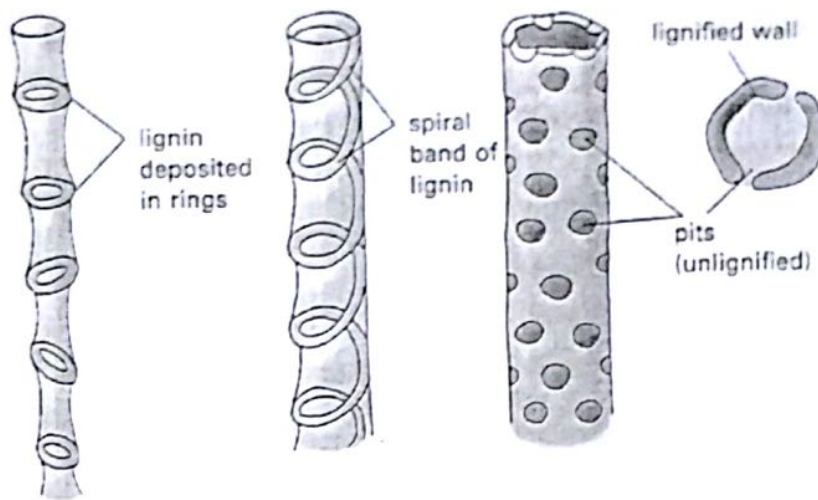


Distribution of vascular bundles in roots and stem



Cross section of leaf

Xylem vessels are long tubes. They are hold open by walls **strengthened** by the chemical **lignin**. Wood is lignified xylem vessels. Thus xylem vessels also help **support** the stem and photosynthesizing tissues of the leaf and further resist forces on the roots which might pull the plant out of the ground.



Entry of water through the roots

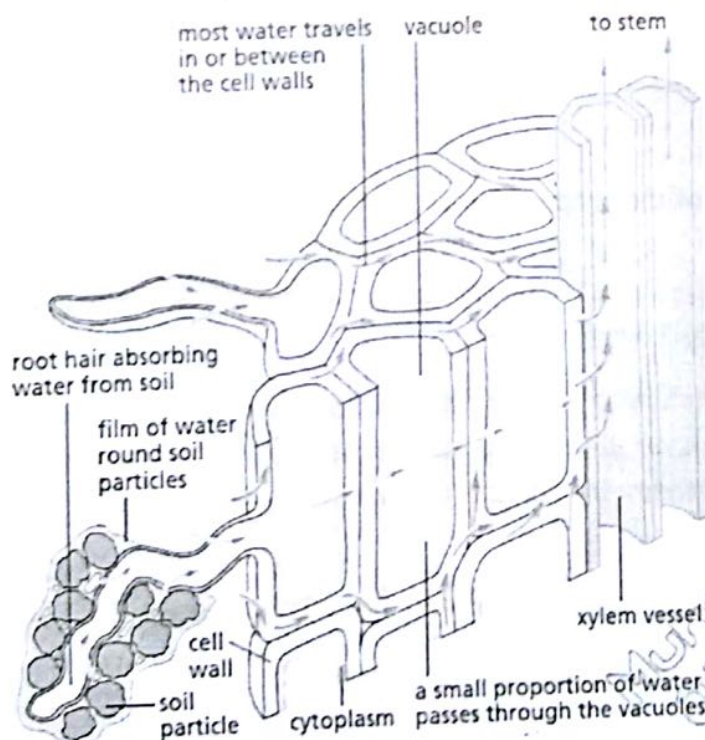
Entry of water takes place at the root hairs. Root hair grows between the soil particles with close contact with water. Mineral salts are dissolved in soil water. Sap of root hair cells has a higher concentration of sugars and salts, It's very **concentrated**. Since the surrounding soil particles has a **high water potential**, water enters the root hair from the soil through **osmosis**.

Entry of mineral salts through the roots

Mineral salts enter the roots as result of **diffusion** and **active transport**.

Diffusion –when the concentration of minerals salts in the soil solution is higher than that in the root hair cell.

Active transport –when the concentration of ions in the soil solution is lower than that in the root hair cell sap. The energy needed for this process comes from cellular respiration in the root hair cells



The path taken by water through a plant

Three forces cause water to rise up a plant includes:

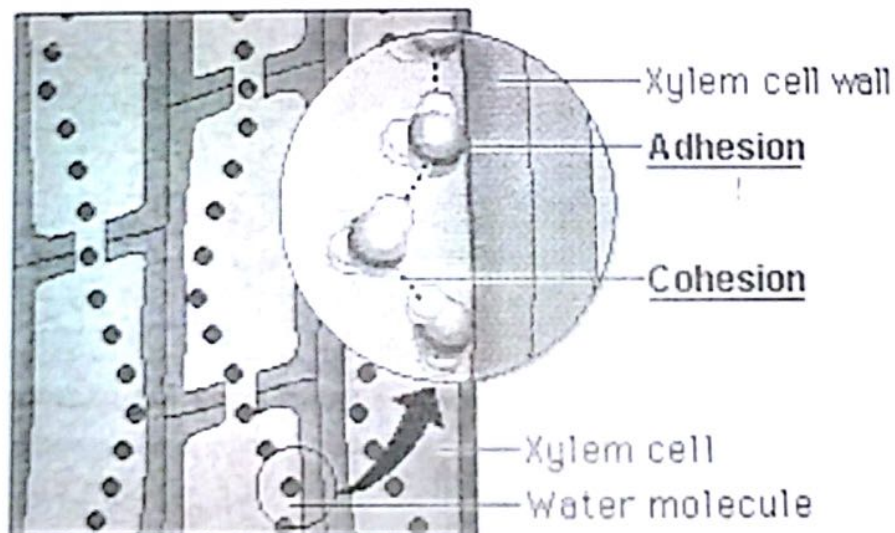
1. Root Pressure
2. Capillary Action
3. Transpiration Pull

Root pressure

As result of osmosis water enters **root hairs**. Osmosis and diffusion also carry water across the root to the vascular bundle of the stem. This ~~causes~~ causes a pressure (called 'root pressure'), forcing water into the xylem, and pushing it along the root towards the stem.

Capillary Action

Once in the xylem of the stem, water is carried upwards by a second force, called **capillary action** 'capillarity'. Capillarity is the movement of liquids upwards through very narrow tubes. This force can be demonstrated by dipping the end of very narrow capillary tubing in water. Xylem vessels have a microscopic bore (diameter), which can be responsible for carrying water 20 cm or more up a plant.



Transpiration pull

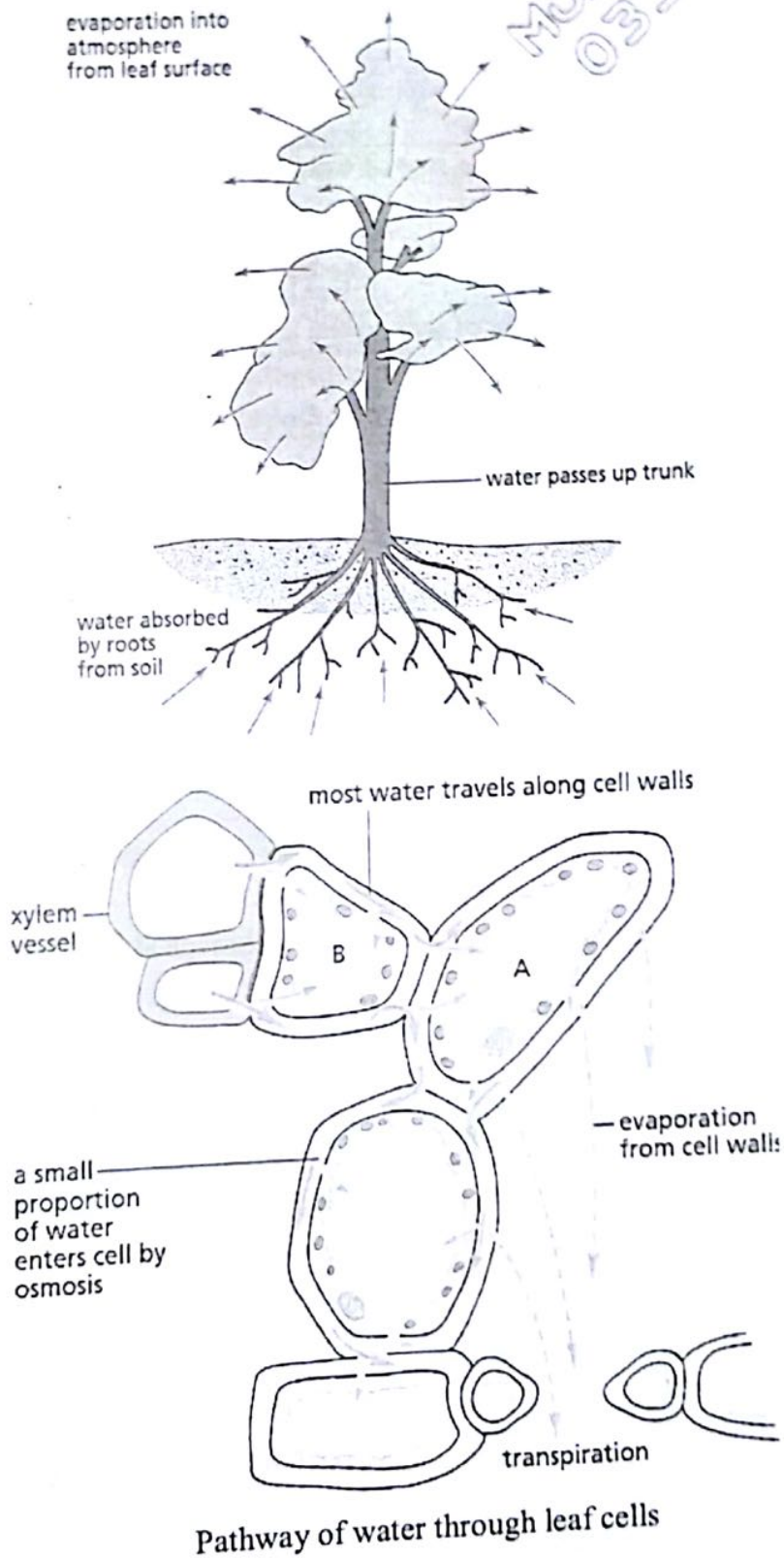
The third force is a result of the evaporation of water from the mesophyll cells of the leaf, and the removal of the water vapour through the stomata of the leaf. This process is called **transpiration**. It creates the force known as 'transpiration pull'. Water is drawn up to the leaf to replace the water that has been lost.

Transpiration pull, in particular, relies on the fact that water molecules are attracted to one another and are not pulled apart as they move up the plant. These forces of **molecular cohesion** ensure that a continuous stream of water and ions travels up the plant. This is known as the transpiration stream.

Transpiration is the loss of water vapour from the leaves through the stomata.

Transpiration takes place in the following way:

1. Water leaves the xylem vessels in the leaf and forms a water film on the walls of the mesophyll cells inside the leaf. This water film is for **dissolving carbon dioxide** for use during photosynthesis.
2. Water from the water film evaporates into the intercellular (leaf) spaces – greatly increasing the humidity of the air inside the leaf.
3. There is now a greater concentration of water vapour molecules inside the leaf than in the atmosphere outside, so the water vapour **diffuses** out through the **stomata** into the atmosphere.



Transpiration occurs as long as the stomata are open for the uptake of carbon dioxide. If the transpiration rate **exceeds** the rate that water can be absorbed from the soil, then water starts to be lost from the plant's cells. The cells **lose their turgidity**, and the plant begins to **WILT**.

Conditions affecting the rate of transpiration

The atmospheric conditions which affect the rate of evaporation of water, also affect the rate of transpiration.

Transpiration speeded up by	Transpiration slowed down by
dry air	humid air
high temperature	low temperature
bright light	dim light

Bright and dim light do not affect the rate of evaporation, but affect the size of the stomata through which the water vapour passes.

Although transpiration can lead to wilting, it also has the following **advantages**:

- It maintains a constant supply of **ions** to the leaves.
- It brings **water** to the **mesophyll** cells for **photosynthesis**.
- It helps to supply **water** to all cell for **metabolic processes** and for **turgidity**.

It helps to **cool** leaves – important in very hot climates.

Investigation: To show that water travels up a stem in the xylem

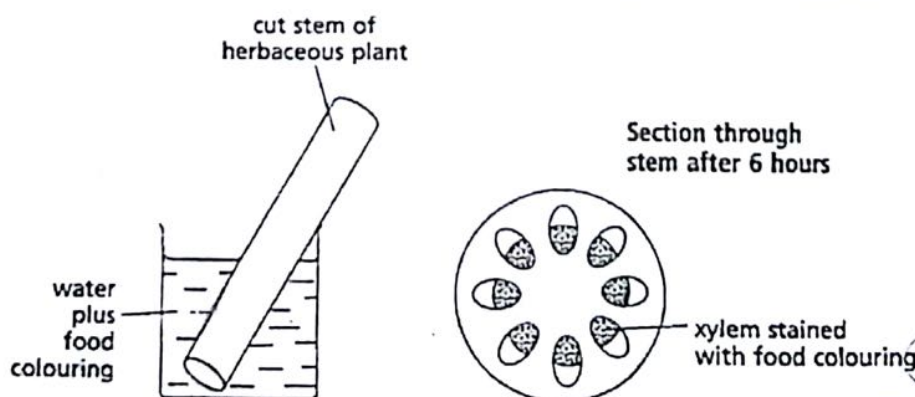
Apparatus

- a beaker
- food colouring
- a soft-stemmed dicotyledonous plant (e.g. a broad bean, or balsam)

Method

Cut the plant stem about 1 cm above the root. Place the stem in water containing food colouring and leave it, as shown below, for about six hours.

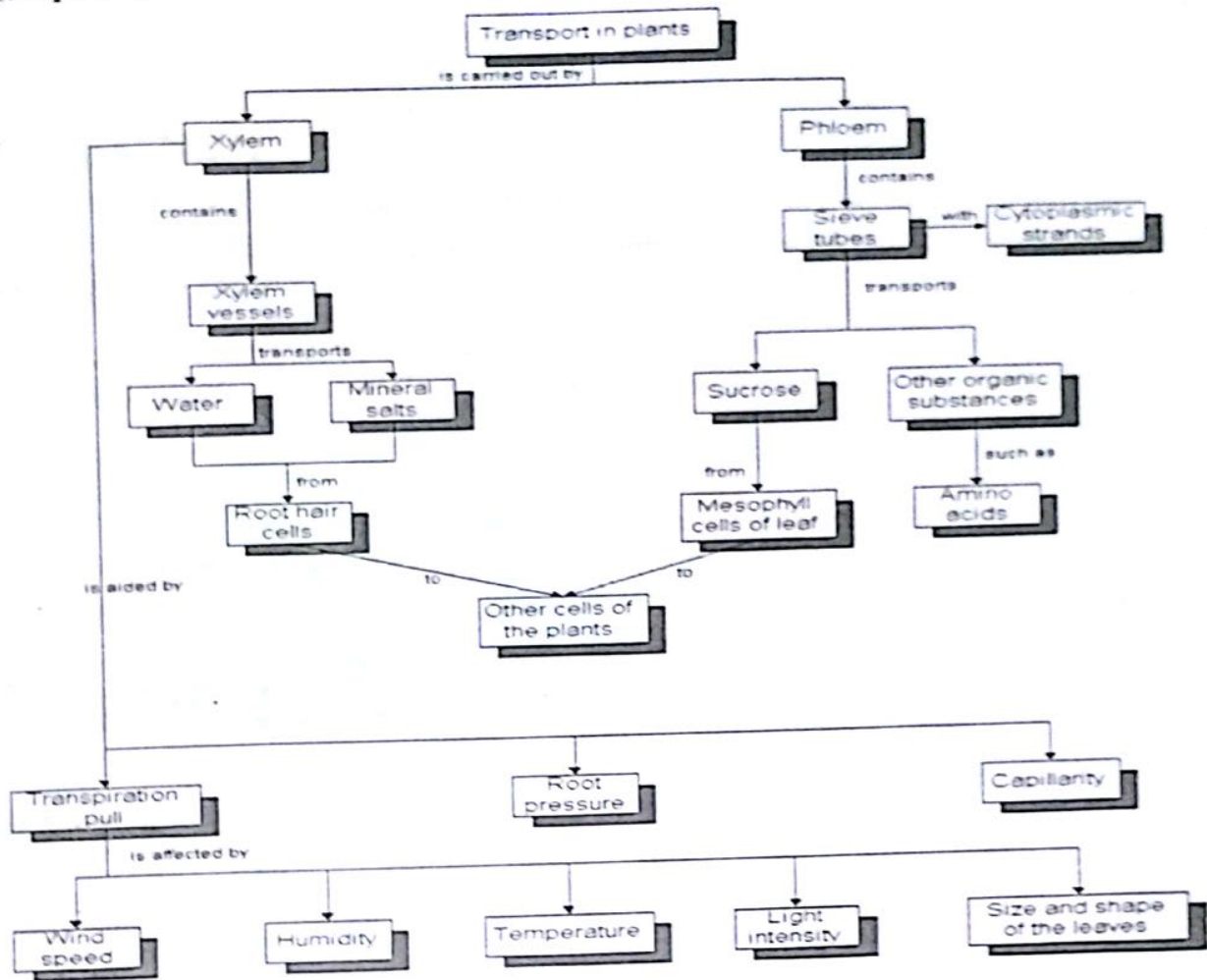
Remove the stem from the beaker and carefully cut it through at 2–3 cm from its base.



Results

The vascular bundles will have been stained by the food coloring. Using a razor blade, carefully cut a very thin section from the stem, and view it under a microscope. It will be seen that the coloured region of the vascular bundle is in the position occupied by the xylem.

Concept Map



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Syllabus Check List Transport in Flowering Plants

After reading chapter are you able to:

- ☐ relate the structure and functions of root hairs to their surface area and to water and ion uptake
- ☐ state that transpiration is the evaporation of water at the surfaces of the mesophyll cells followed by the loss of water vapour from the leaves through the stomata
- ☐ describe:
 - how water vapour loss is related to cell surfaces, air spaces and stomata
 - the effects of air currents (wind), and the variation of temperature, humidity and light intensity on transpiration rate
 - how wilting occurs
- ☐ investigate, using a suitable stain, the pathway of water in a cut stem
- ☐ explain the movement of water through the stem in terms of transpiration pull
- ☐ identify the positions of xylem and phloem tissues as seen in transverse sections of unthickened, herbaceous, dicotyledonous roots, stems and leaves
- ☐ state the functions of xylem and phloem.

O-LEVEL BIOLOGY

Topic 7: Transport in Humans

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Syllabus 2017 – 2019

Content

7.1 Circulatory system

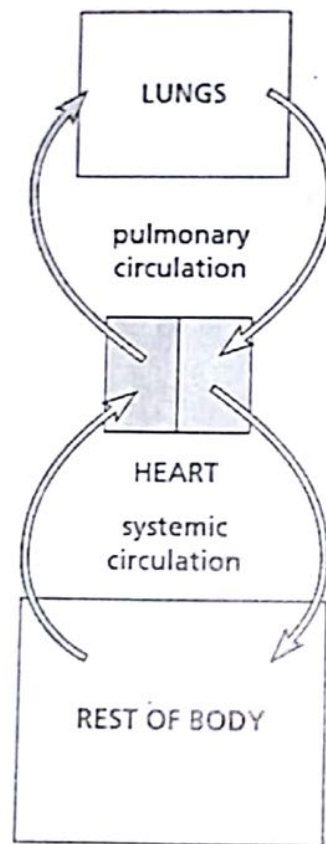
TRANSPORT IN HUMANS

The term 'transport system', in human, refers to the **circulatory system**. Like the transport system in flowering plants, it is made up of a system of tubes. Unlike flowering plants, there is a **pump** and a system of **valves** to ensure that the liquid (**blood**) within the tubes flows through them in only **one direction**.

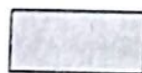
Dual circulation

During **one** complete circulation of the human (mammalian) body, blood travels **twice** through the heart:

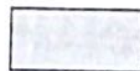
1. Blood arrives at the heart from the other organs of the body, then travels to the **lungs**.
2. From the lungs, blood travels back to the heart, then to the other **organs** of the body.



key



deoxygenated blood



oxygenated blood

As shown above, the heart is completely divided into two halves so it can play its part in the dual circulation.

Blood needs to travel only a short distance from the heart to reach the lungs, which lie either side of the heart. Blood has to travel much further to reach other parts of the body, such as the toes. Blood leaving the heart in the **lesser** circulation (to the lungs) is not therefore under as much pressure as it is in the **greater** circulation. (blood must always be able to reach the tissues of the fingertips, even when the arms are raised.)

The main blood vessels of the body

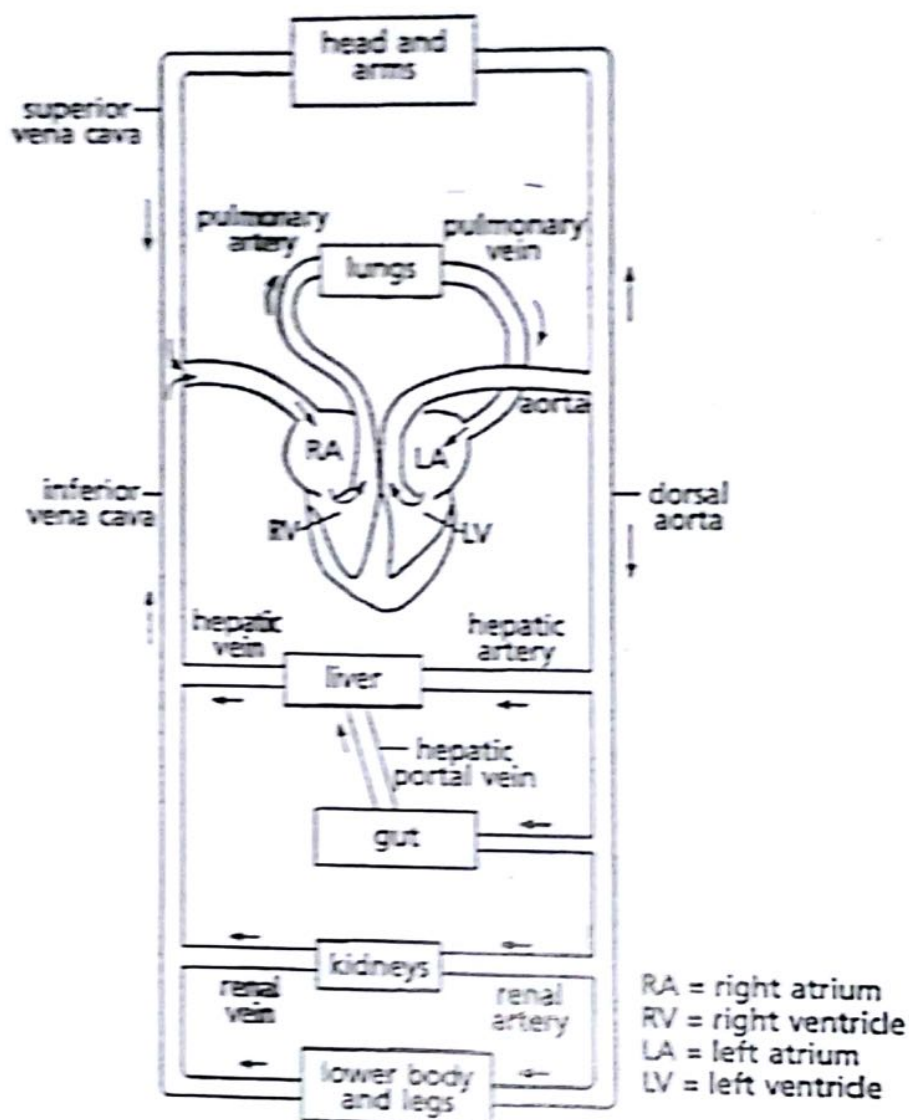
Blood always **leaves** the heart in arteries. These vessels have thick muscular walls, and can withstand the high pressure of the blood. A large artery is called an **aorta**; a small one is called an **arteriole**.

Blood **returns** to the heart, under much lower pressure, in thinner-walled vessels called **VEINS**. A large vein is a **vena cava**; a small one is a **venule**.

Blood passes from arterioles to venules through microscopic blood vessels called capillaries.

Blood vessel	Structure	Explanation of how structure is related to function
artery	thick, tough wall with muscles, elastic fibres and fibrous tissue lumen quite narrow, but increases as a pulse of blood passes through valves absent	Carries blood at high pressure – prevents bursting and maintains pressure wave. The large arteries, near the heart, have a greater proportion of elastic tissue, which allows these vessels to stand up to the surges of high pressure caused by the heartbeat. This helps to maintain blood pressure. High pressure prevents blood flowing backwards.
vein	thin wall – mainly fibrous tissue, with little muscle or elastic fibres lumen large valves present	Carries blood at low pressure. To reduce resistance to blood flow To prevent backflow of blood. Contraction of body muscles, particularly in the limbs, compresses the thin-walled veins. The valves in the veins prevent the blood flowing backwards when the vessels are compressed in this way. This assists the return of venous blood to the heart.
capillary	permeable wall, one cell thick, with no muscle or elastic tissue lumen approximately one red blood cell wide valves absent	This allows diffusion of materials between the capillary and surrounding tissues. White blood cells can squeeze between cells of the wall. Blood cells pass through slowly to allow diffusion of materials and tissue fluid. Blood is still under pressure.

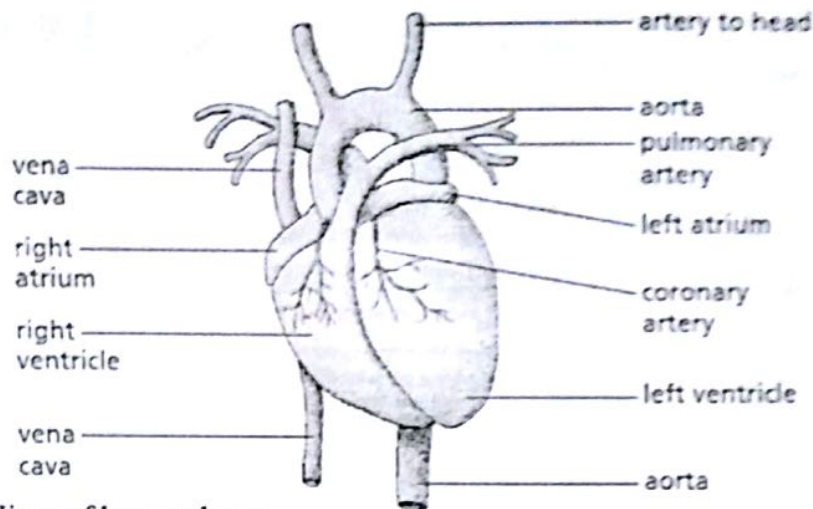
Figure below shows the names of the blood vessels associated with some of the main organs of the body.



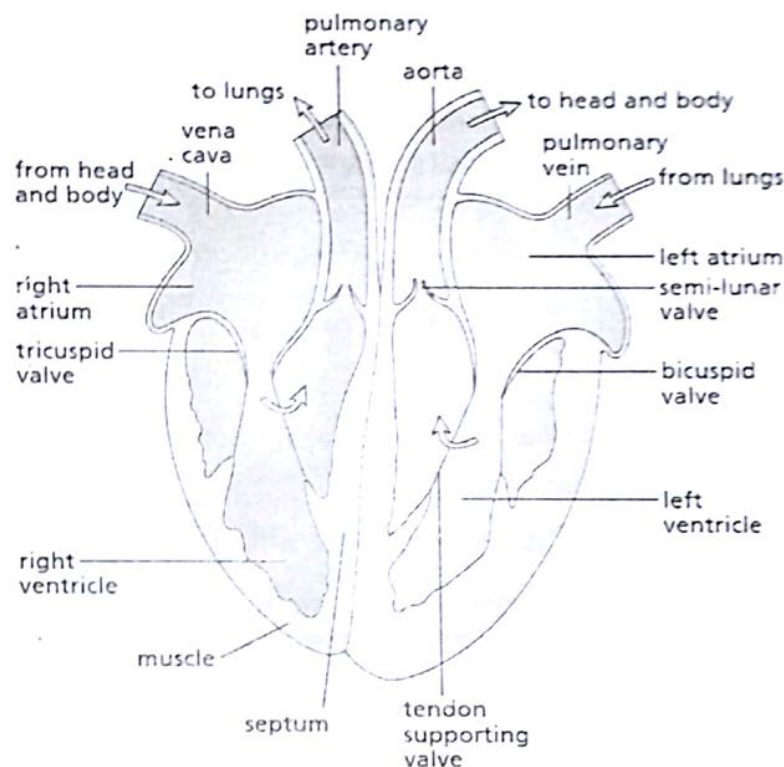
The heart and how it functions

Important facts about the heart:

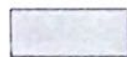
- (i) It is a muscular pump.
- (ii) It is made of special muscle (cardiac muscle) which has the ability to contract rhythmically (even without stimulation).
- (iii) It never tires or suffers from cramp.
- (iv) It beats about 70 times per minutes in the average adult at rest.
- (v) It has four chambers, all with similar volumes when full – two atria 'on top' (in mammals which walk upright) of two ventricles.
- (vi) Atria (singular: 'atrium') have thin walls and receive the blood.
- (vii) Ventricles have thick muscular walls to pump the blood out of the heart under pressure. The left ventricle has the thickest walls, to send blood round the body.
- (viii) A system of valves ensures one-way flow of blood through the heart.



External View of human heart



key

deoxygenated
bloodoxygenated
blood

Heart vertical section

- (ix) A wave of contraction (called **systole**) passes over the heart from atria to ventricles. It forces blood from the atria into the ventricles, then forces blood out of the ventricles. As the ventricles contract, the mitral and tricuspid valves are slammed shut causing the 'lubb' sound of the heartbeat.
- (x) The heart muscle then relaxes (**diastole**). As the ventricles relax, the semi-lunar valves close to stop blood being drawn back into the ventricles. The closing of the valves causes the 'dupp' sound. There is then a pause before the next cycle of systole-diastole (or 'lubb-dupp' of the heart).



1 **Atrial systole.** Both atria contract. Blood flows from the atria into the ventricles. Backflow of blood into the veins is prevented by closure of the valves in the veins.

2 **Ventricular systole.** Both ventricles contract. The atrioventricular valves are pushed shut by the pressurised blood in the ventricles. The semilunar valves in the aorta and pulmonary artery are pushed open. Blood flows from the ventricles into the arteries.

3 **Ventricular diastole.** Atria and ventricles relax. The semilunar valves in the aorta and pulmonary artery are pushed shut. Blood flows from the veins through the atria and into the ventricles.

→ pressure exerted by contraction of muscle

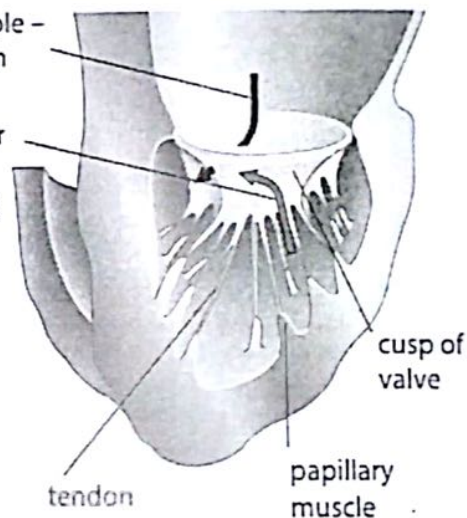
→ movement of blood

During **atrial systole**, the pressure of the blood is higher in the atrium than in the ventricle, and so forces the atrioventricular valve open. During **ventricular systole**, the pressure of the blood is higher in the ventricle than in the atrium. The pressure of the blood pushes up against the cusps of the atrioventricular valve, pushing it shut. Contraction of the papillary muscles, attached to the valve by tendons, prevents the atrioventricular valve from being forced inside-out.

Atrioventricular valve

atrial systole – valve open

ventricular systole – valve shut

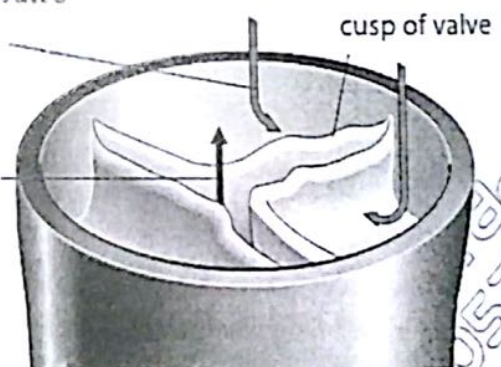


During **ventricular systole**, the pressure of the blood forces the semilunar valves open. During **ventricular diastole**, the pressure of the blood in the arteries is higher than in the ventricles. The pressure of the blood pushes into the cusps of the semilunar valves, squeezing them shut.

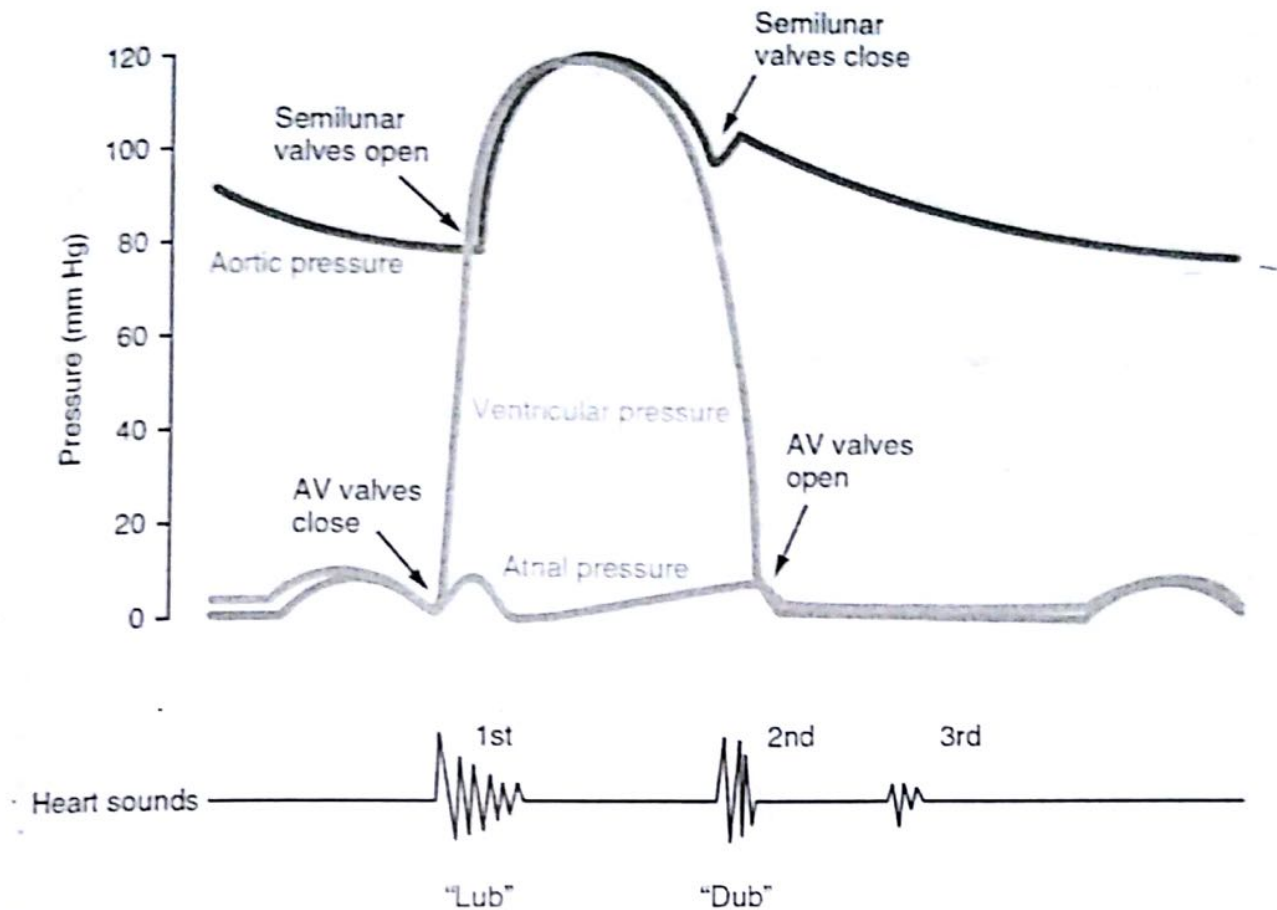
Semilunar valve

ventricular diastole – valve shut

ventricular systole – valve open



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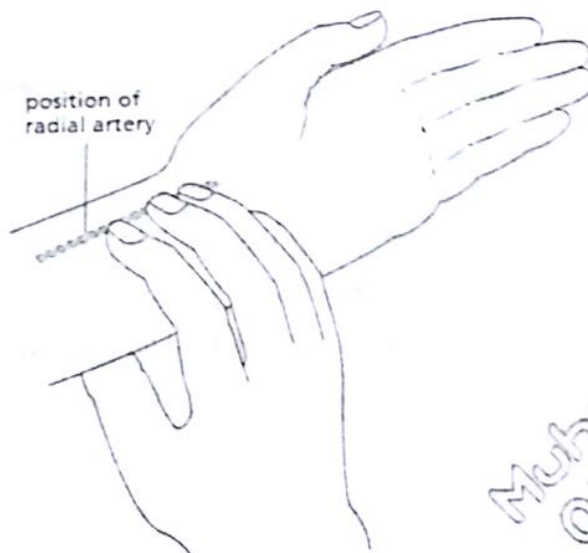


Each beat of the heart creates a surge of pressure in the arteries, called the pulse.

There is no such surge in the veins, where blood flows smoothly under much lower pressure. Veins, however, have semi-lunar valves which ensure that there is no back flow of blood.

The pulse beat in an artery can be located by gently pressing on the wrist at the base of the thumb using your middle and index fingers.

The pulse is usually expressed as the number of heart beats per minute. One easy method of measuring pulse rate is to count the number of beats in a short period of time – say 15 seconds – then calculate the rate per minute.



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Investigation 9.1

To show the effect of physical activity on pulse rate

Method

The number of pulse beats per minute is counted in a person at rest. This is done three times, and each result is recorded. The **average** number of pulse beats per minute is calculated.

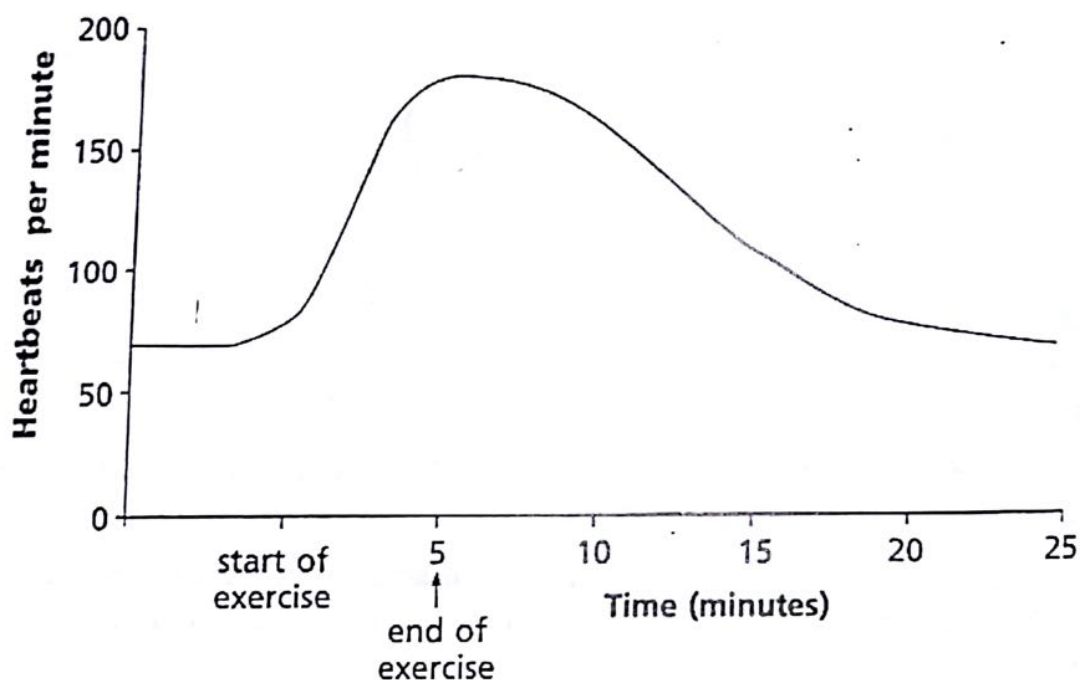
About five minutes of exercise is performed (e.g. running, or stepping on and off a stair step).

The number of pulse beats in 10 seconds is counted and recorded. After 20 seconds, the number of beats is again counted over a 10-second period.

The process is continued for 10 minutes.

Each recorded number is multiplied by 6 to obtain the rate per minute.

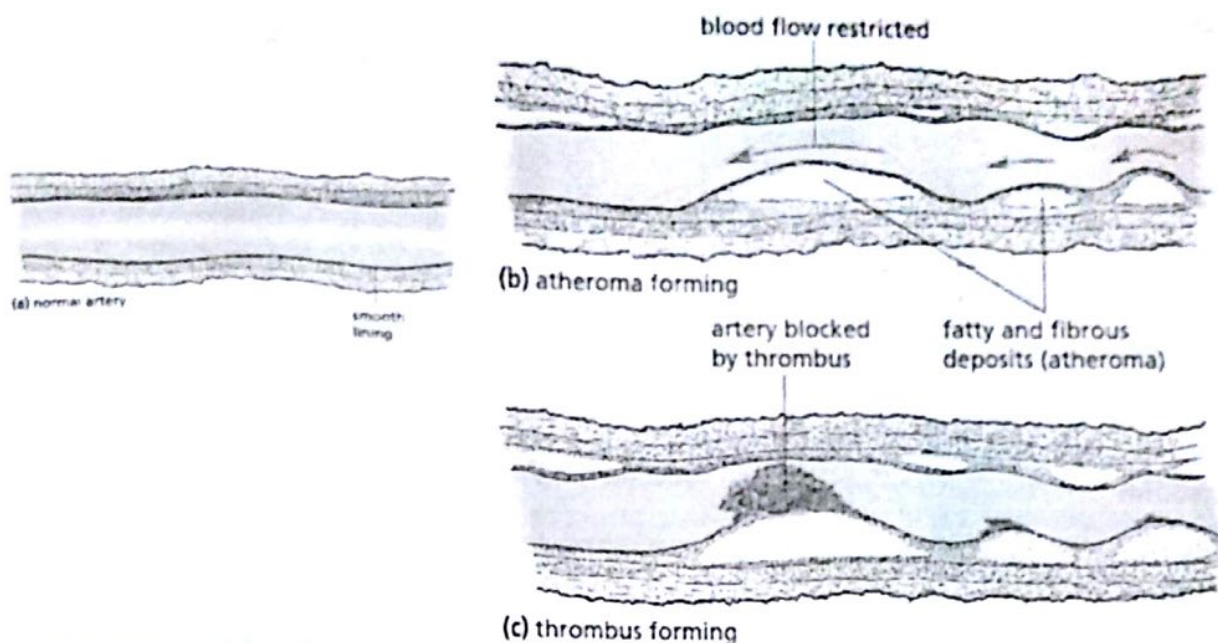
The results can be used to draw a graph to show how the rate of heartbeat gradually returns to normal after exercise. The fitter the subject, the quicker the pulse rate returns to normal.



Heart disease

Diet is important for a healthy heart, but, like all muscles, the heart benefits from **exercise**.

The harmful effects of **atheroma** on the **coronary artery** are well understood these days. The heart may also be affected by cigarette smoking. **Carbon monoxide** in cigarette smoke encourages the build up of atheroma, and **nicotine** increases the tendency for **blood to clot**. The coronary artery may therefore not supply enough blood to the heart muscle. People who lead **stressful** lives are also at risk of heart disease. Stress causes the release of raised levels of the hormone adrenaline, which constricts artery walls. In this way, stress adds to existing problems of partially blocked arteries.



To decrease the risk of heart disease:

- restrict the intake of animal fats and cholesterol
- avoid obesity
- do not smoke
- settle for a less stressful lifestyle
- take regular exercise.

Structural features of the main components of blood

Features and functions of blood cells

Red blood cells (RBCs)

Structure

- Biconcave discs
- Extremely small ($2\mu m \times 7\mu m$) ($1\mu m = \frac{1}{1000}mm$).
- No nucleus
- Live for only 120 days
- Made in the bone marrow
- Destroyed in the liver
- Cytoplasm contains the red iron-containing protein called haemoglobin
- Flexible, so they can pass through the very narrow capillaries
- There are 4,000,000–5,000,000 RBCs per mm^3 of blood

Red blood cell
no nucleus



Their microscopic size, biconcave shape and very large numbers provide an **enormous surface area** for the function given below.

Functions

The **uptake and carriage** of **oxygen**, by the haemoglobin in the form of oxyhaemoglobin.

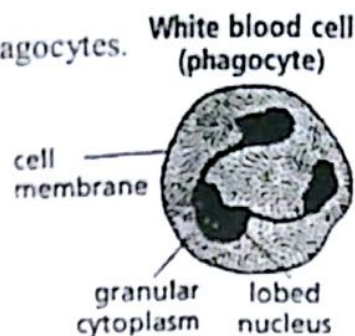
White blood cells

There are two types of white blood cells; lymphocytes and phagocytes.

Phagocytes

Structure

- (i) About 10 μm in diameter.
- (ii) A **lobed nucleus**.
- (iii) Made in the bone marrow.
- (iv) Capable of movement ('amoeboid' movement), and can squeeze out of capillaries.
- (v) There are about 5,000 per mm^3 of blood.



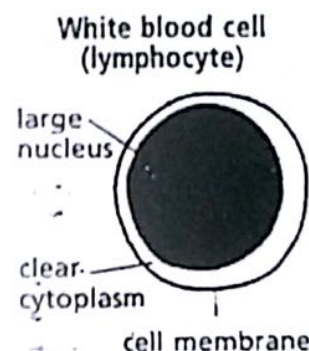
Function

They carry out PHAGOCYTOSIS. That is, they **ingest** potentially harmful **bacteria**, to prevent or overcome infection.

Lymphocytes

Structure

- (i) About 10 μm in diameter.
- (ii) A **large round nucleus** occupying almost all of the cell.
- (iii) Made in **lymph nodes**.
- (iv) There are about 2,000 per mm^3 of blood.



Function

They produce antibodies which 'stick' to bacteria and clump them together ready for being ingested by phagocytes. Some antibodies are in the form of antitoxins. Antitoxins neutralise poisons (toxins) in the blood which have been released by invading bacteria.

Antibodies are **specific** to the organism against which they are produced. They may stay in the blood only for a few weeks, or for a lifetime. If they stay for a lifetime, they give life-long immunity against the effects of that particular disease-causing agent (or **pathogen**).

Tissue rejection

Our immune system is unable to distinguish between possible harmful protein (e.g. a pathogenic bacterium) and potentially useful 'foreign' protein (e.g. a transplanted heart or kidney). There is always a danger of **TISSUE REJECTION** when a transplant operation is carried out. There is less chance of rejection if the protein structure in the transplanted organ is similar to the proteins of the recipient. Organs from a (close) relative are far less likely to be rejected because the protein types are similar.

Platelets

Structures

- (i) Fragments of cells.
- (ii) Made in bone marrow.
- (iii) There are 250,000 per mm^3 of blood.

Platelets



Function

Platelets play a part in **blood clotting** and help to block holes in damaged capillary walls.

Plasma

Structure

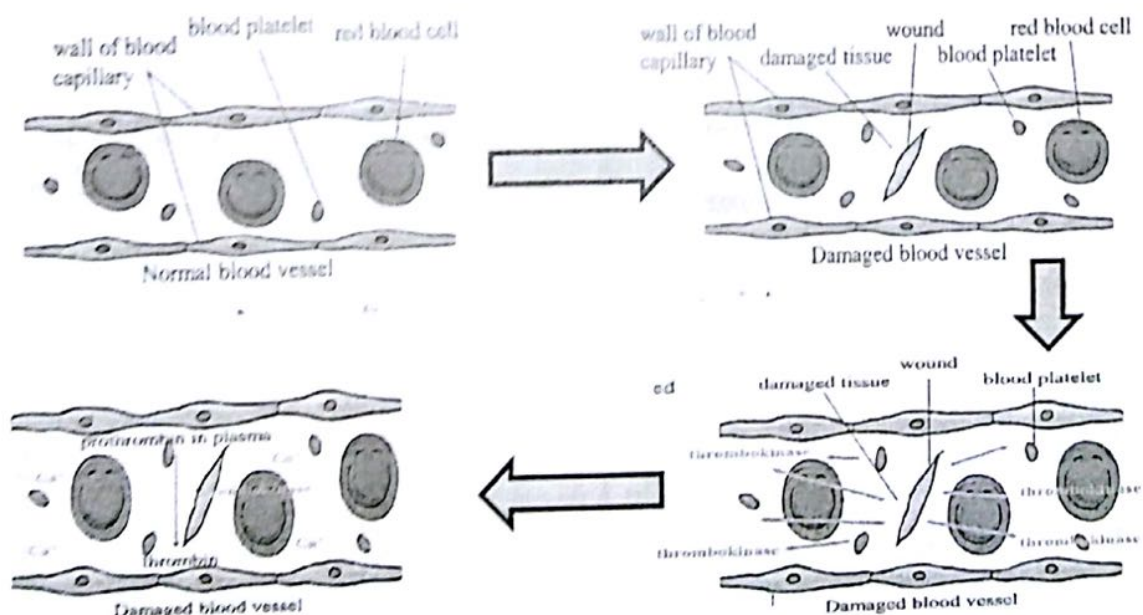
- (i) Pale yellow watery fluid.
- (ii) Contains the following materials **in solution**:
 - digested foods (**amino acids, glucose**)
 - vitamins
 - ions (salts)
 - excretory materials (**urea, carbon dioxide**)
 - hormones
 - plasma (or 'blood') proteins (e.g. antibodies, and fibrinogen)
 and also:
 - fat droplets (in suspension)
 - heat
 - red and white blood cells and platelets.

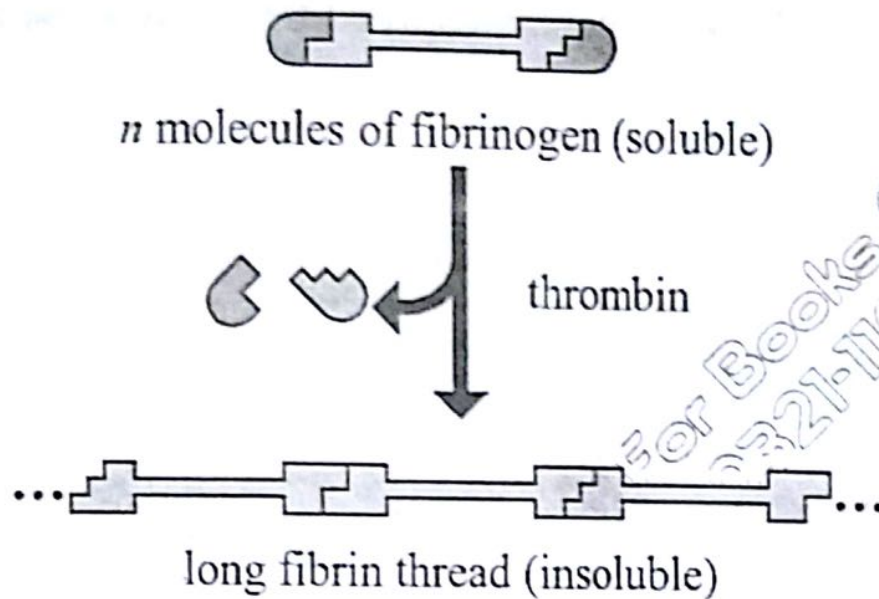
Function

The plasma carries all materials from where they are absorbed or produced to the parts of the body where they are needed or excreted. For example, plasma carries carbon dioxide from the cells of the body to the lungs.

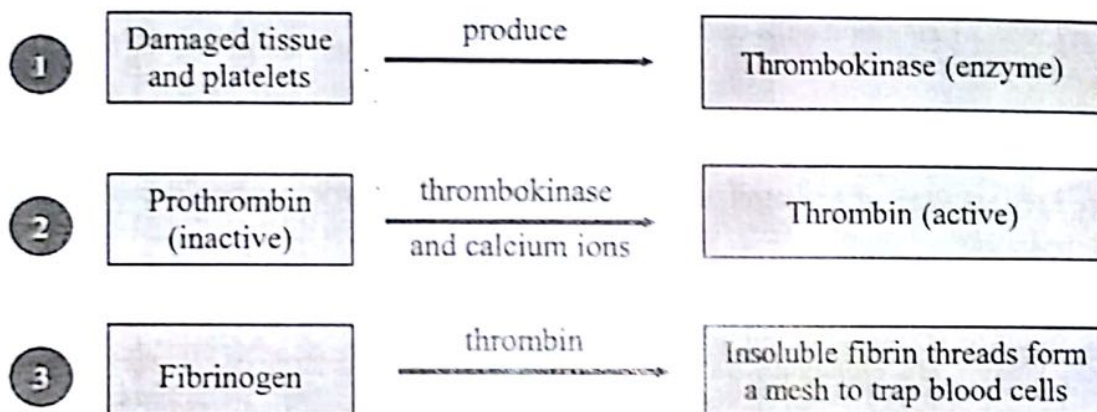
Mechanism of blood clotting

When blood vessels are damaged, damaged tissues and blood platelets release an enzyme known as **thrombokinase**. Thrombokinase converts the protein **prothrombin**, normally present in the plasma, into **thrombin**. Calcium ions must be present before this can take place. Thrombin is also an enzyme. It catalyses the conversion of the soluble protein **fibrinogen** to insoluble threads of **fibrin**. Fibrin threads entangle blood cells and the whole mass forms a clot.





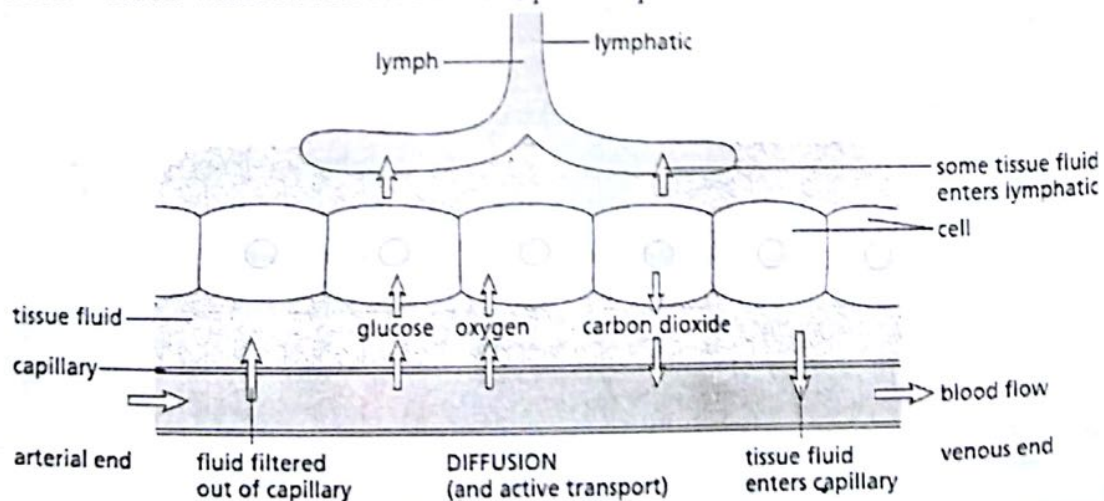
Clotting process can be summarized in following three reactions:

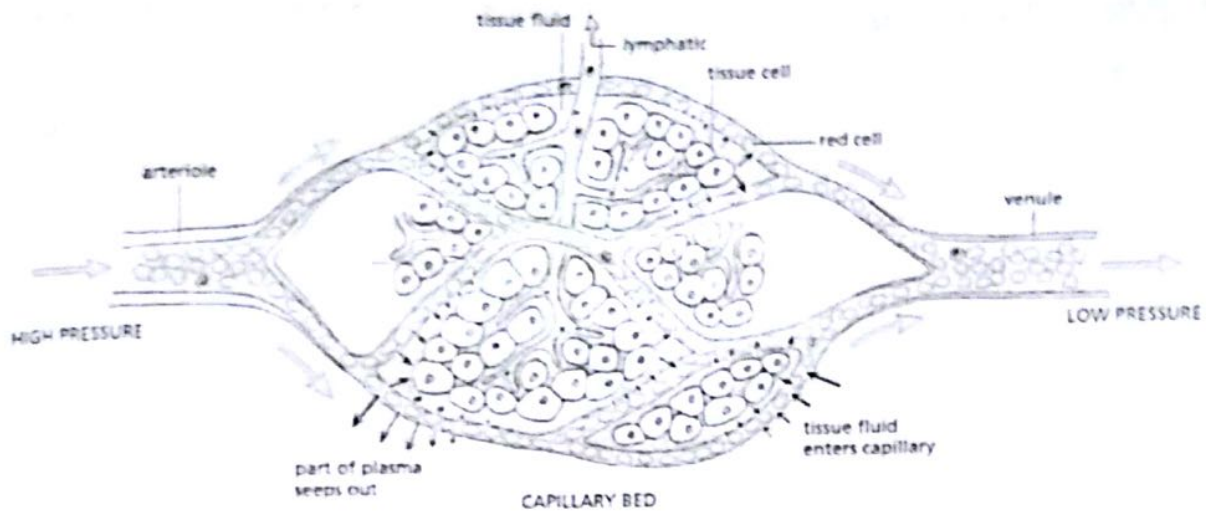


How substances in the capillaries reach the cells of the body

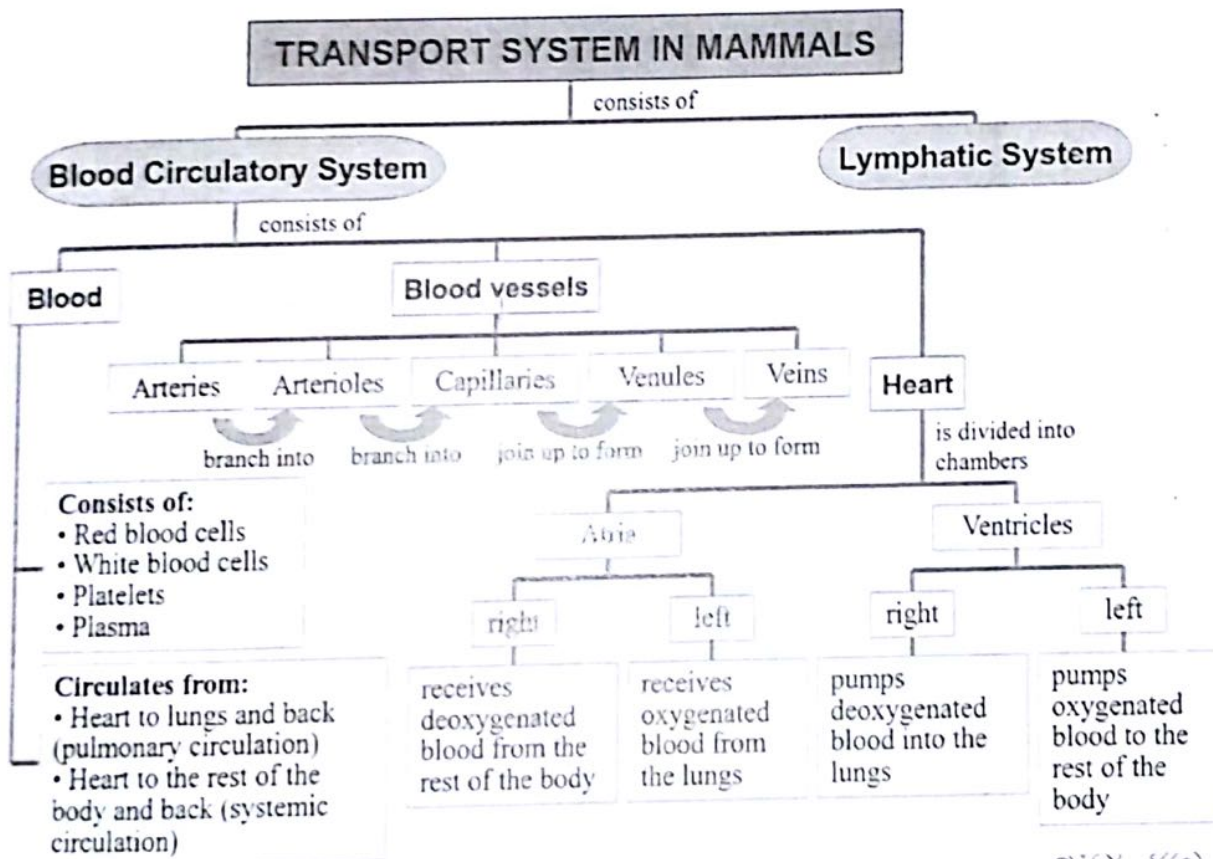
Capillaries leak, so some – but not all – of the materials in plasma can escape. All blood cells, except phagocytes, are too large to leave the capillaries. By their own effort, phagocytes are able to squeeze out between the cells in the capillary walls. Most plasma protein molecules are too large to pass out of the capillaries. All the smaller molecules in solution pass out to bathe the cells in **tissue fluid**.

Tissue fluid = blood **without** red blood cells, plasma proteins and some white blood cells.





Concept Map



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Syllabus Check List Transport in Humans

After reading chapter are you able to:

- ☐ describe the circulatory system as a system of tubes with a pump and valves to ensure one-way flow of blood
- ☐ describe the double circulation in terms of a low-pressure circulation to the lungs and a high-pressure circulation to the body tissues and relate these differences to the different functions of the two circuits
- ☐ name the main blood vessels that carry blood to and from the heart, lungs, liver and kidneys
- ☐ describe the structure and function of the heart in terms of muscular contraction and the working of valves
- ☐ compare the structure and function of arteries, veins and capillaries
- ☐ investigate and state the effect of physical activity on pulse rate
- ☐ describe coronary heart disease in terms of the occlusion of coronary arteries and state the possible causes (diet, stress and smoking) and preventive measures
- ☐ identify red and white blood cells as seen under the light microscope on prepared slides, and in diagrams and photomicrographs
- ☐ list the components of blood as red blood cells, white blood cells, platelets and plasma
- ☐ state the functions of blood:
 - red blood cells – haemoglobin and oxygen transport
 - white blood cells – phagocytosis, antibody formation and tissue rejection
 - platelets – fibrinogen to fibrin, causing clotting
 - plasma – transport of blood cells, ions, soluble food substances, hormones, carbon dioxide, urea, vitamins and plasma proteins
- ☐ describe the transfer of materials between capillaries and tissue fluid.

O-LEVEL BIOLOGY

Topic 8: Respiration

NOTES BY

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Syllabus 2017 – 2019

Content

- 8.1 Aerobic respiration
- 8.2 Anaerobic respiration
- 8.3 Human gas exchange

RESPIRATION

All living organisms need energy to move, excrete, grow, reproduce and maintain themselves. This required energy is retrieved from food (food contains chemical energy). Respiration is a characteristic of all living organisms. **Respiration is the release (not 'production') of energy from food substances in all living cells.** In other words respiration is the oxidation of food substances with the release of energy. This reaction is carried out in mitochondria. The food substance involved is usually glucose.

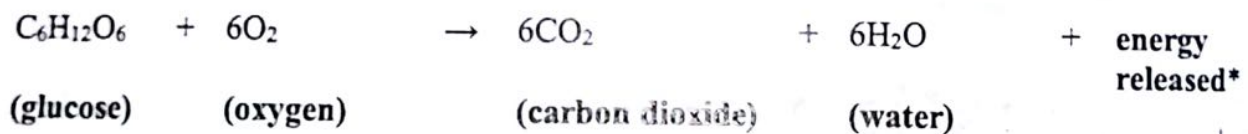
There are **two** forms of respiration:

1. Aerobic Respiration
2. Anaerobic Respiration

Aerobic respiration

This is the **release of relatively large** amounts of energy by using **oxygen** to break down food stuffs.

Aerobic respiration usually takes the form of the **oxidation of glucose** in the cytoplasm of living cells. The process is controlled by **enzymes**. It unlocks the chemical energy in the glucose molecule, releasing it for metabolic activities, and releasing also the waste products **carbon dioxide and water**.



*16.1 kJ/g glucose

The energy that is released may be used in the following ways:

- for **muscle contraction** resulting in movement and locomotion
- to help link together amino acids in order to **manufacture proteins** (such as enzymes and proteins used for growth and repair)
- for **cell division** and therefore **growth**
- for **active transport** of chemicals through cell membranes (e.g. the uptake of glucose through the villus walls)
- conversion into **electrical** energy in the form of **impulses** along nerve cells
- conversion into **heat** energy to **maintain a constant body temperature**.

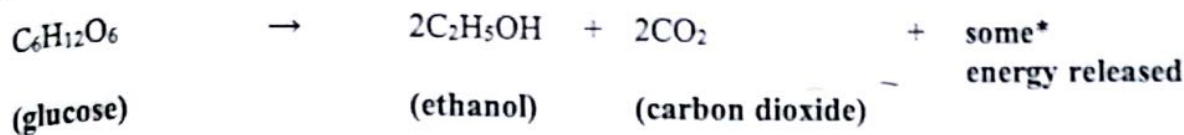
Anaerobic respiration

This is a form of respiration in which **relatively small** amounts of energy are released by the breakdown of food substances **in the absence** of oxygen.

Anaerobic respiration can take place in yeast (single cell – unicellular organism) as well in muscles. So it is actually a process by which **glucose is partially broken down in absence of oxygen with relatively release of small amount of energy** and it is also called **fermentation**. There are two types of anaerobic respiration or fermentation; **Alcoholic fermentation** and **lactic acid fermentation**.

In the yeast cell

Yeast respire anaerobically and produce **ethanol** along with production of **carbon dioxide**. This type of anaerobic respiration is also called **alcoholic fermentation**. Yeast cannot be very active under such situation.

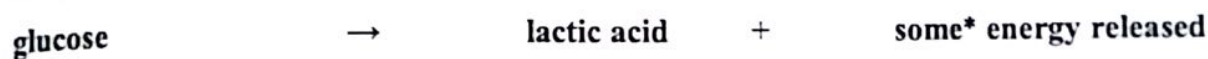


*1.17 kJ/g glucose

Less energy is released than in aerobic respiration because the alcohol molecule is relatively large and still contains a considerable amount of chemical energy.

In the human body

Anaerobic respiration also occurs in the **human body** – especially in **muscles**. It happens when there is not enough oxygen reaching the cells to convert all the glucose into carbon dioxide and water. Instead, the glucose is partially broken down, without oxygen, to **lactic acid**, with only a limited amount of energy being released.



*0.83 kJ/g glucose

The circulatory system carries the lactic acid away from the muscle to the liver, where it is oxidized to carbon dioxide and water. Some of the lactic acid is oxidized to energy and converts remaining into glucose. But this all happens **after the period of exercise has finished or during resting**. The oxygen being used for this process is said to be used to pay off the **oxygen debt**.

Panting results in removal of carbon dioxide and take in more oxygen. Heart beats faster so that more oxygen can be brought to the muscles.

If the circulation is inefficient, high levels of lactic acid in the muscles may lead to **cramp** and **muscular pain**.

DIFFERENCES	
Aerobic Respiration	Anaerobic Respiration
Use Oxygen	Do not use oxygen
No alcohol or lactic acid made	Alcohol or lactic acid made
Large amount of energy released	Small amount of energy released
CO ₂ always released	CO ₂ sometimes released

Gaseous exchange in man

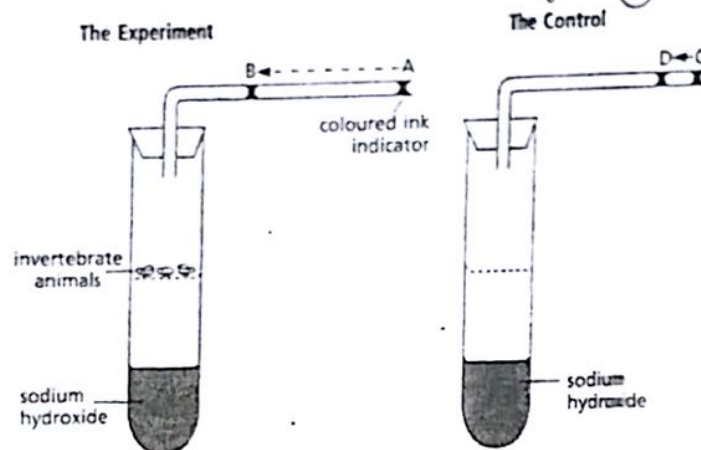
Oxygen enters the blood from the lungs. **Breathing** is a muscular, pumping action that takes in air from the atmosphere and moves it to the lungs. Breathing in (inspiration) is responsible for presenting air with its oxygen to the surface in the lungs where gaseous exchange will take place. Expiration pushes the air, now containing waste carbon dioxide, back into the atmosphere (breathing out).

The differences between inspired and expired air

Inspired air	Expired air
20% oxygen	16% oxygen
0.04% carbon dioxide	4% carbon dioxide
relatively dry	saturated
at air temperature	at body temperature
relatively dirty	relatively clean

Practical demonstrations can show these differences.

Demonstration.



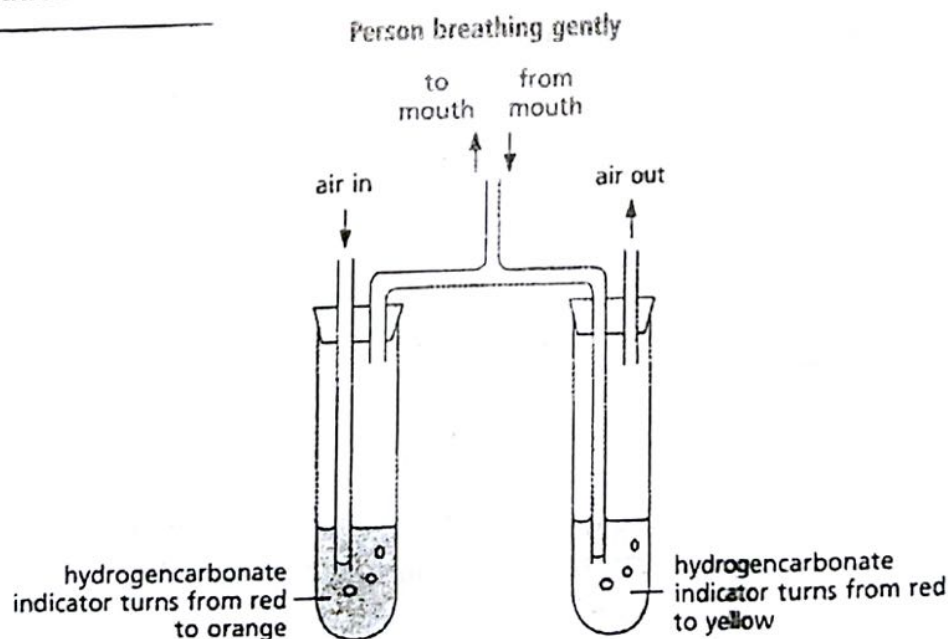
For each molecule of oxygen taken in by the animals, a molecule of carbon dioxide is given out. The molecule dissolves in the sodium hydroxide, decreasing the volume within the apparatus. The indicator thus moves from A to B.

Note: when all the oxygen in the tube has been used up, the total volume inside the apparatus would have decreased by 20%.

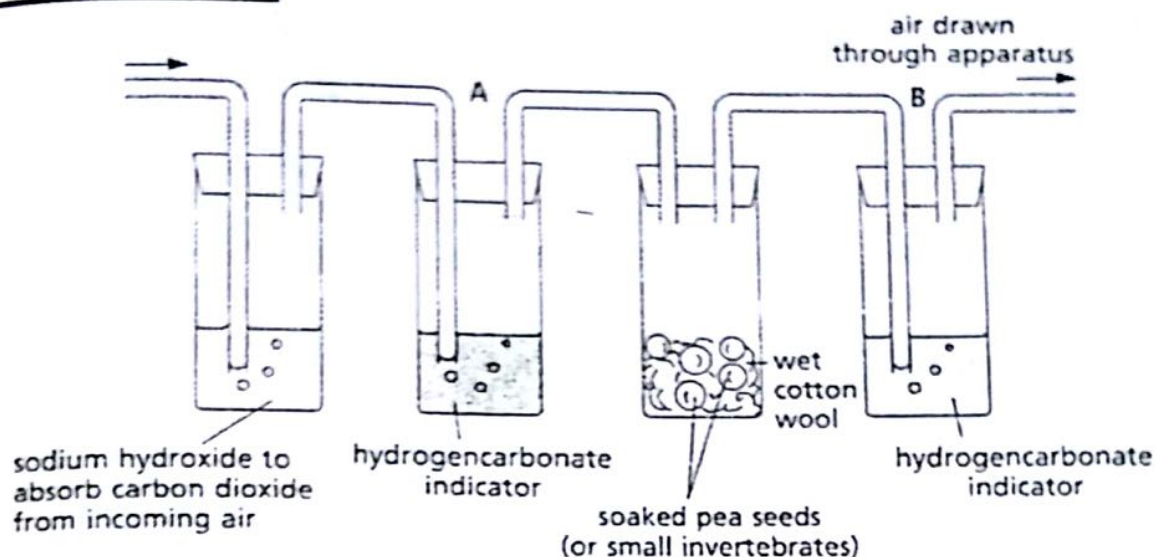
The control

In the same period of time, the only carbon dioxide to dissolve in the sodium hydroxide is that already in the air. The indicator moves only from C to D.

Demonstration



Demonstration



- A. The hydrogencarbonate indicator remains red, showing that no carbon dioxide is passing on to the next tube.
- B. The hydrogencarbonate indicator changes from red to yellow, showing that carbon dioxide is present. The carbon dioxide is evolved by the respiring peas.

Depending on the need for oxygen in the body (and the need to remove waste carbon dioxide), the **rate** and **depth** of breathing may vary.

More oxygen is used, and more carbon dioxide is released, when we are active. This can be demonstrated in the following way.

Investigation: To show the effect of exercise on the rate of breathing

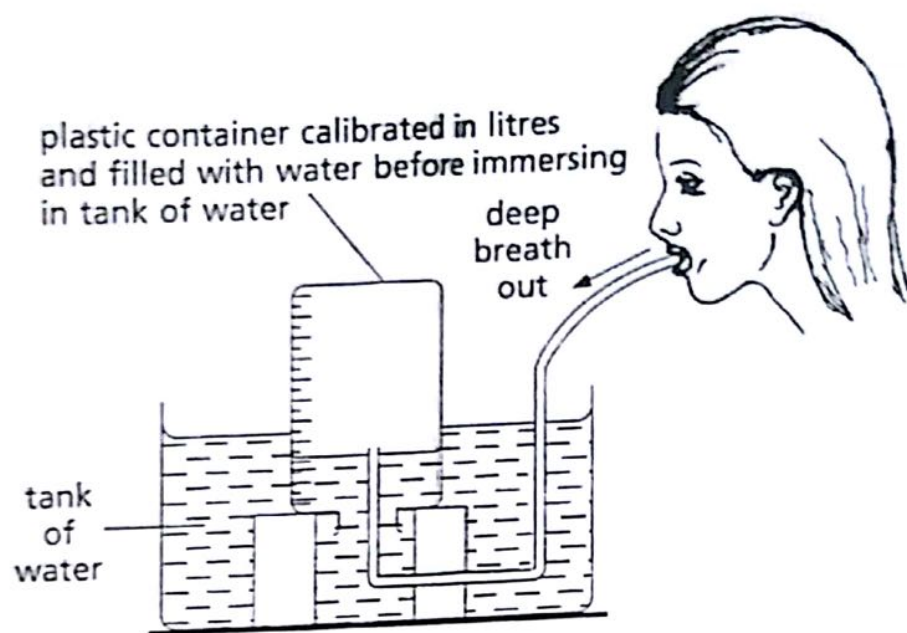
Count the number of breaths taken in one minute by a person at rest (it is easier to count someone else's breathing rate than it is to count your own). Do this **three** times and take an average (around 15 breaths per minute).

The person should then perform five minutes of exercise. Count the number of breaths in a 10-second period every 30 seconds for 10 minutes.

Calculate the rate per minute, and plot a graph of breathing rate against time.

Investigation: To show the effect of regular exercise on the depth of breathing

Regular exercise can affect the volume of air a person is able to inspire, then expire, in one deep breath. This can be demonstrated by using the simple **respirometer** shown below.



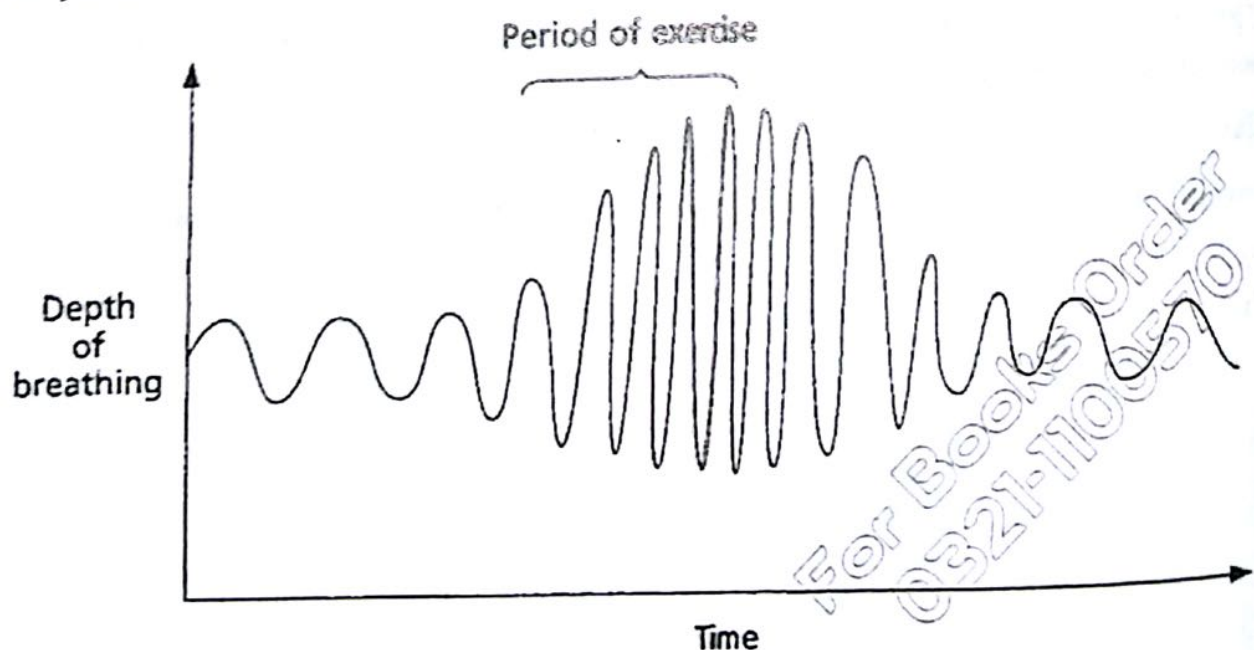
Organize a group of athletes and a group of non-athletes to breathe in as far as they can, then breathe out through the rubber tube as far as they can. Measure the volume of water expelled from the container by each person.

Calculate the average volume per person for the athletes, and the average volumes for the non-athletes. Compare the results.

Athletes should be able to exhale a greater volume of air (and thus, be able to breathe more deeply).

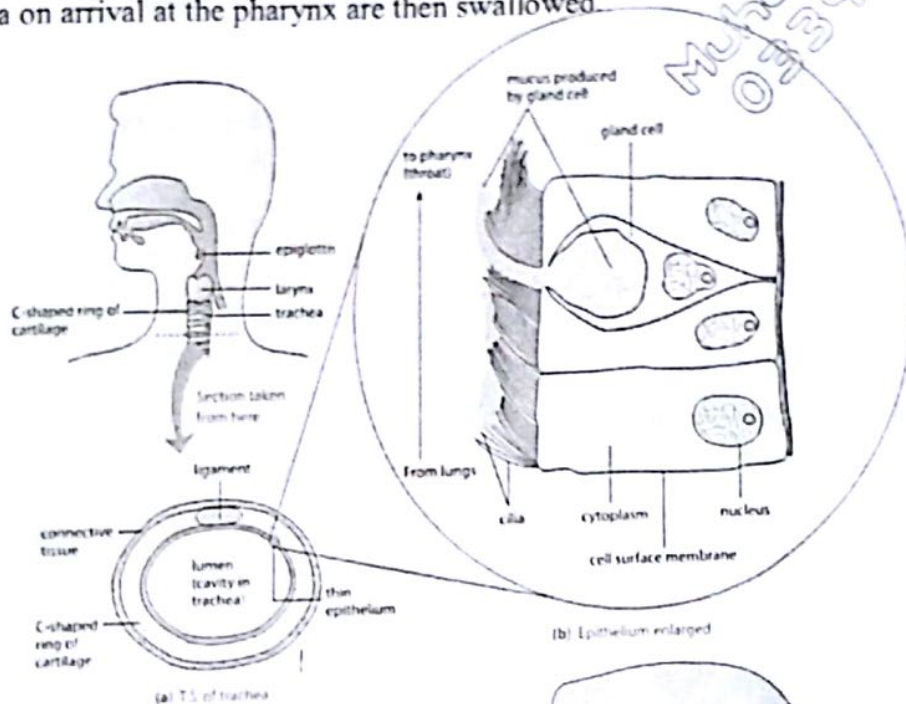
The immediate effect of exercise on the depth of breathing may be successfully demonstrated only with a commercial respirometer. A person breathes in and out through a tube connected to a piece of electronic equipment which measures the depth and the frequency of breathing. The respirometer produces a graph of the results.

If a person measured the depth and rate of their breathing before a period of exercise, then every 30 seconds after exercise, the results would be similar to the graph shown below.

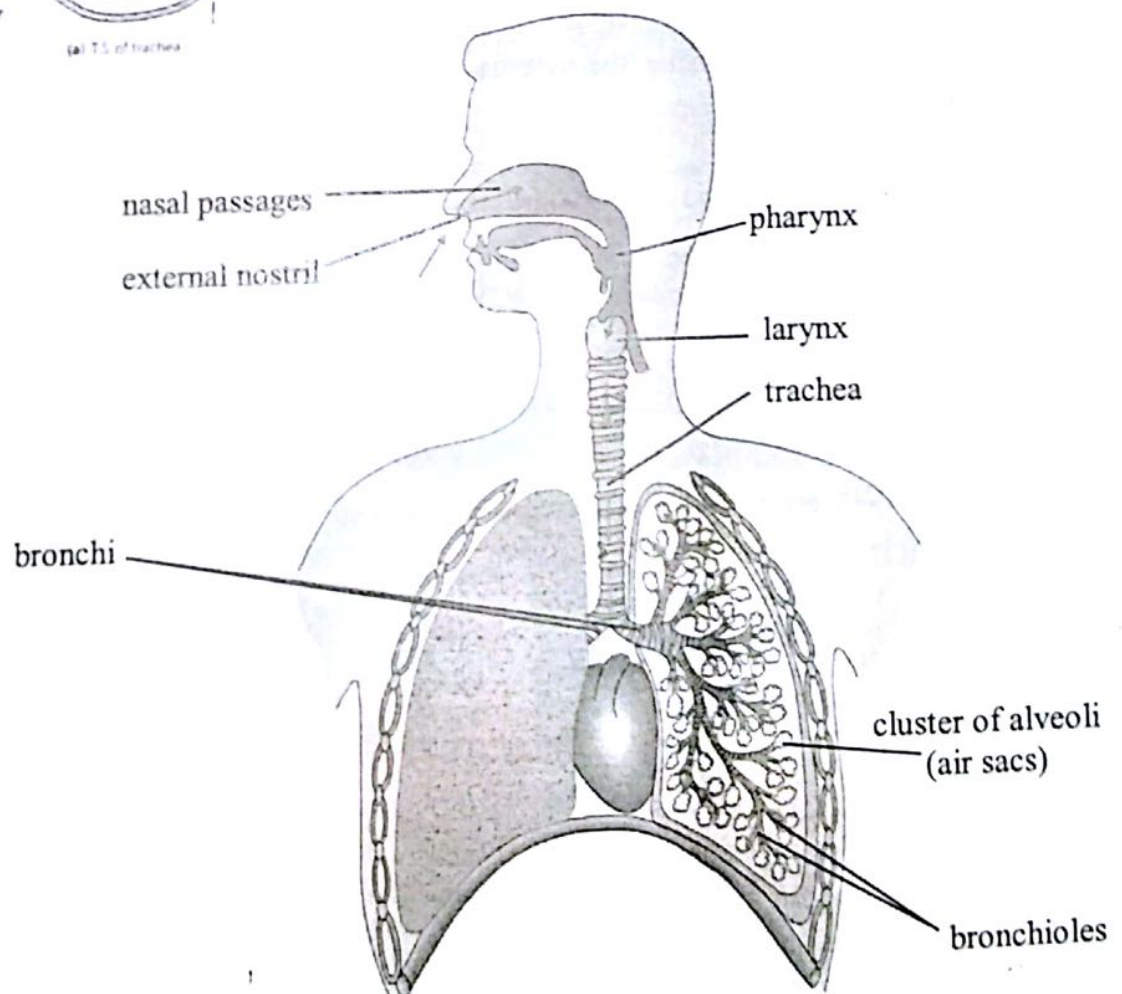


Path of air through the respiratory system

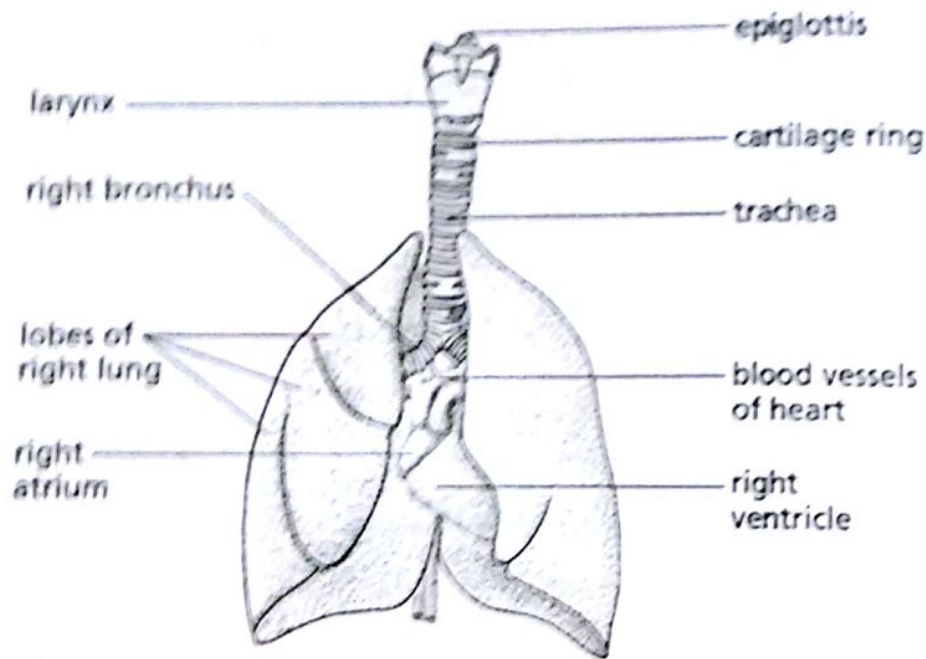
The only connection between the thorax and the higher pressure of the outside atmosphere is via the mouth and nose. Air from the atmosphere is **forced** towards the region of lower pressure. It passes through the mouth and nose, down the **trachea**, through the **bronchi** and **bronchioles** and into the **alveoli**. As it passes through the trachea, it is cleaned. Cells in the walls of trachea manufacture a sticky **mucus** in which dust and bacteria are trapped. This mucus is then swept up towards the pharynx by millions of **cilia** – (microscopic hair-like cell extensions) which line the trachea and which beat upwards in a wave-like action. Mucus + dust + bacteria on arrival at the pharynx are then swallowed.



atmosphere
↓
external nostril
↓
nasal passages
↓
pharynx
↓
larynx
↓
trachea
↓
bronchi
↓
bronchioles
↓
Alveoli



External structure of human respiratory system

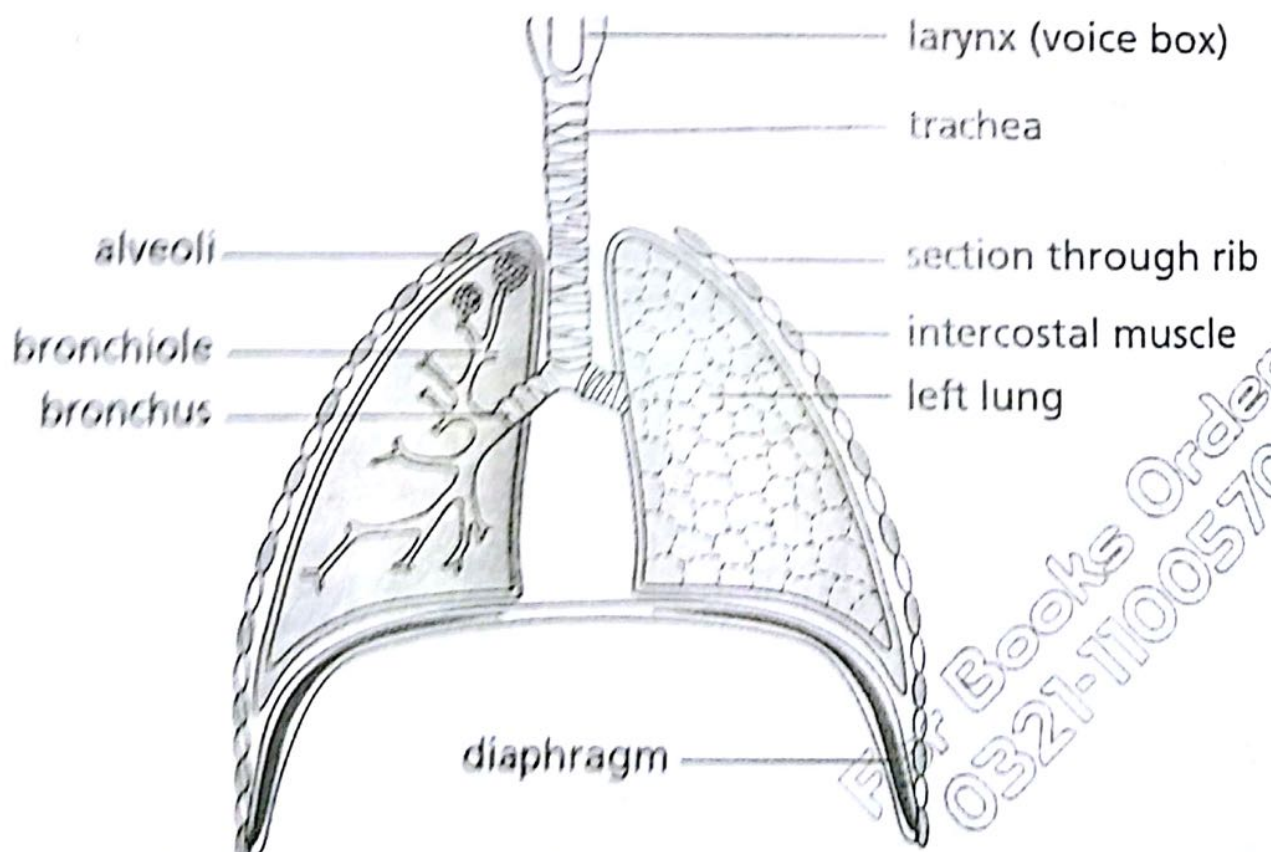


The structure of the respiratory organs

A pair of **lungs** lie in the airtight **thoracic** ('chest') cavity, as shown in the diagram below.

During breathing, the lungs are inflated and deflated by the action of muscles which help to form the thorax. They are the **intercostal** muscles (between the ribs) and the muscles of the **diaphragm**. The diaphragm is a sheet of muscle lying below the lungs, separating them from the abdomen. It is curved upwards (towards the lungs) like a dome.

These muscles work to alter the **volume** of the thoracic cavity, which, in turn, alters the **pressure** within the thoracic cavity.



During inspiration

1. The (external) **intercostal muscles contract**. This causes the ribs to swing **up and out** – increasing the volume of the thorax ('front' to 'back').
2. The muscles of the **diaphragm contract**, pulling it **flat** – further increasing the volume of the thorax (this time 'top' to 'bottom').

When you inhale, you...

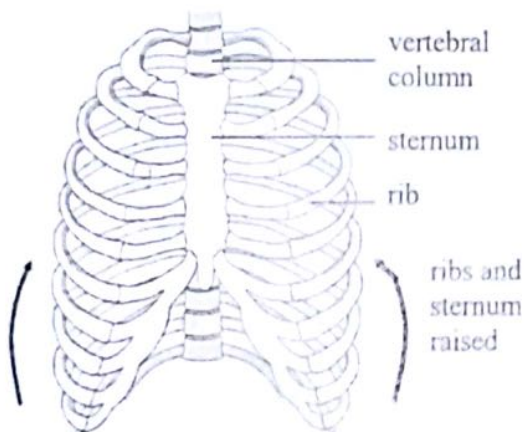
Relax your
Internal intercostal muscles and
Contract your
External intercostal muscles

R
I
C
E

The resulting increase in volume of the thorax **decreases its pressure**.

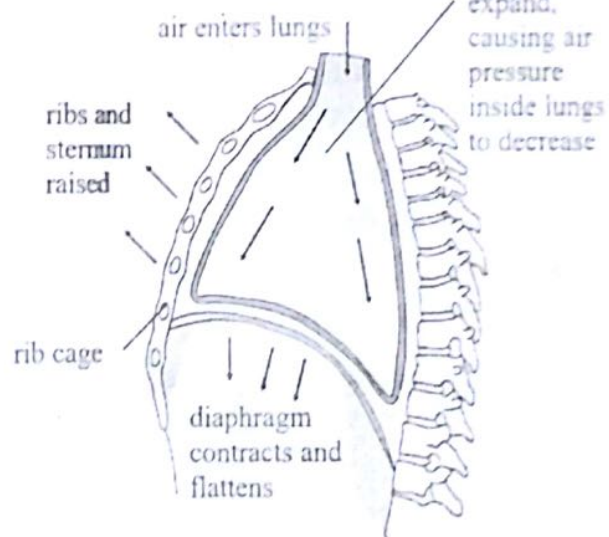
Movement of rib cage during inspiration

Front view



Ribs swing up and
increase volume of thorax

Side view



During expiration

1. The (external) **intercostal muscles relax** – the ribs swing **down and in**.
2. The **diaphragm muscles relax** and the diaphragm **domes upwards** again.

When you exhale, your...

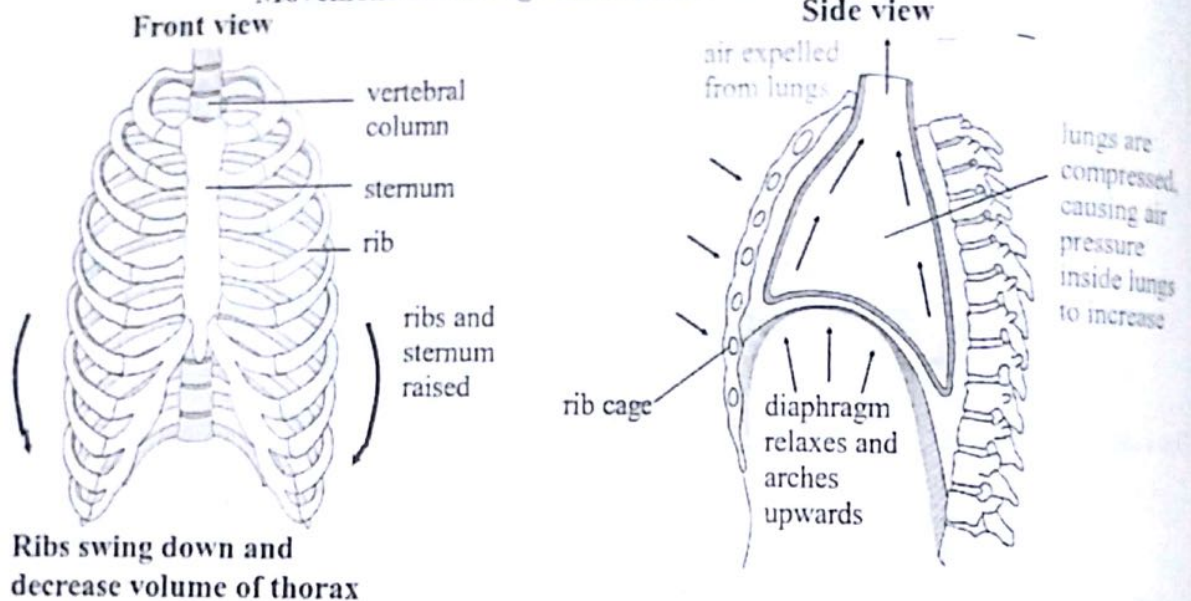
External intercostal muscles
Relax and your
Internal intercostal muscles
Contract

E
R
Muhammad Shahid
0334-4463339
C

These actions **decrease** the volume of the thoracic cavity, **increasing** its pressure. Air is **forced** back out into the atmosphere.

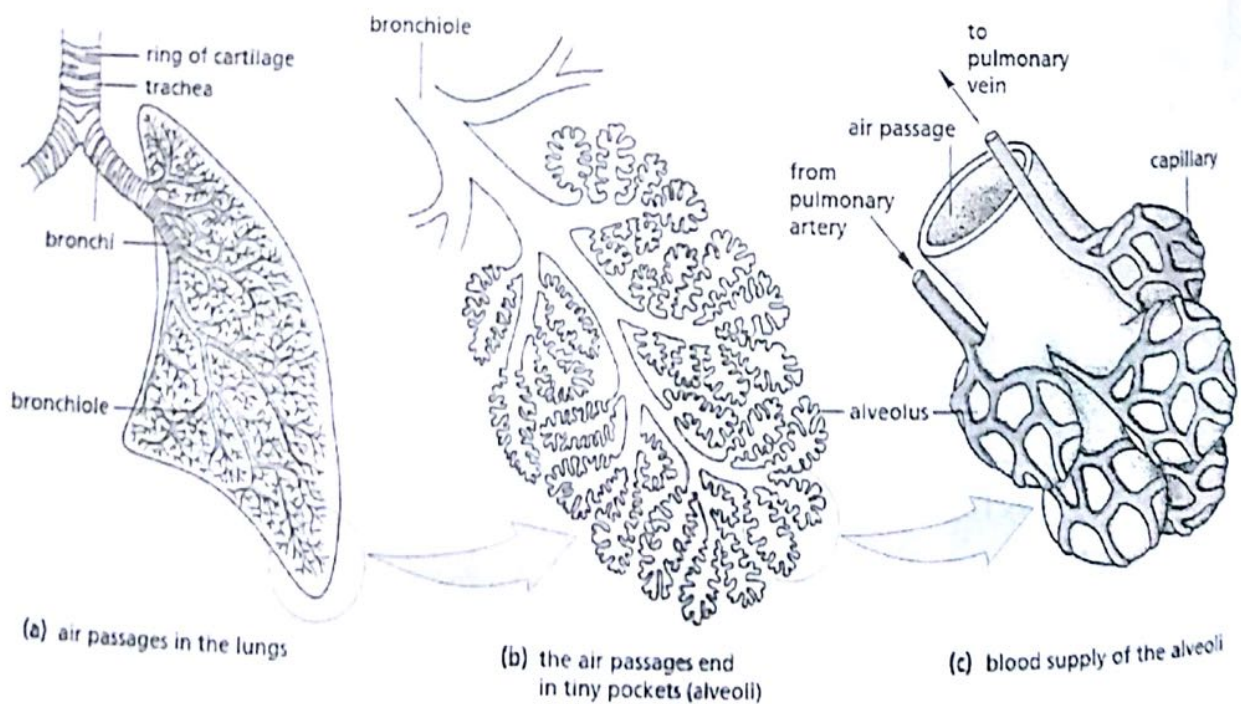
These are also smaller **internal** intercostal muscles. They **relax** during inspiration and **contract** during **expiration** to help provide some force to the action.

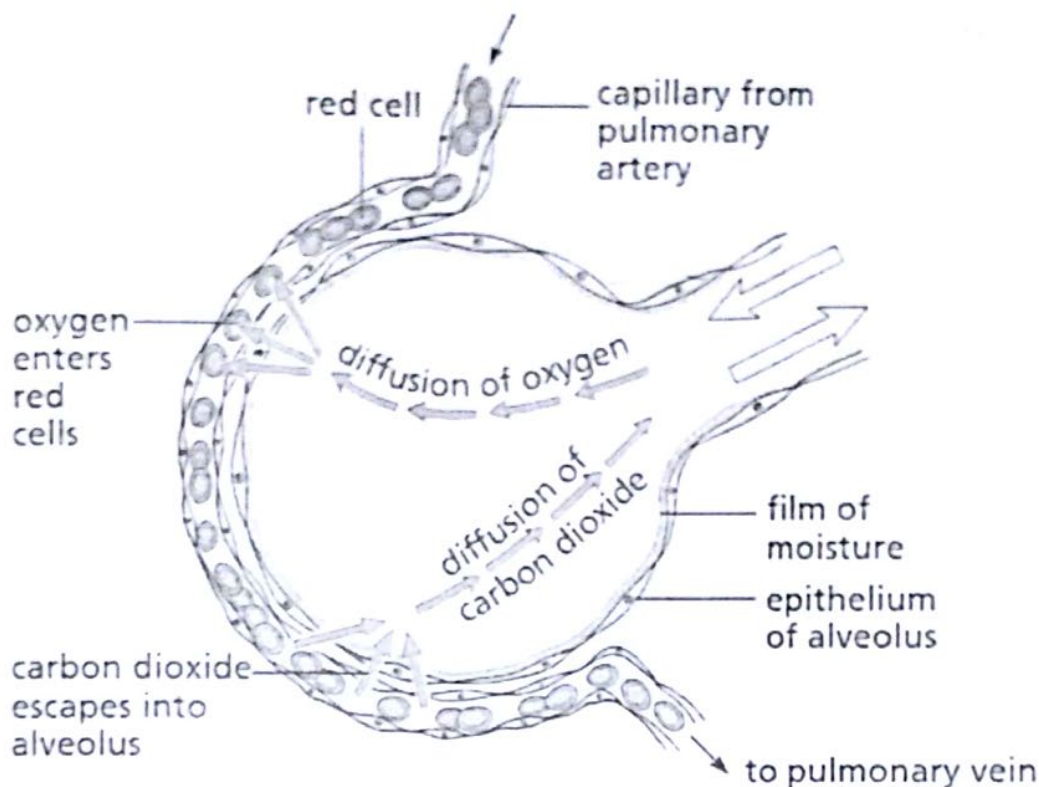
Movement of rib cage during expiration



How alveoli are adapted for the process of gaseous exchange

- The millions of alveoli provide a **large surface area** for gaseous exchange.
- The walls of the alveoli are covered with a **layer of water** to dissolve the gases.
- The walls are only **one cell thick** for quick and easy **diffusion** of gases in solution.
- They are richly supplied with **capillaries** for rapid transport of the gases.





The effect of respiratory diseases on the process of gaseous exchange

Chronic bronchitis

Bronchitis is an inflammation of the airways ('chronic' means extending over a long period of time). It leads to an overproduction of mucus, which tends to block the bronchi and bronchioles. This makes breathing difficult, and decreases the efficiency of the gaseous exchange process. Less oxygen reaches the blood, which affects organs such as the heart and the brain, and the extremities. It also causes a distressing cough.

Emphysema

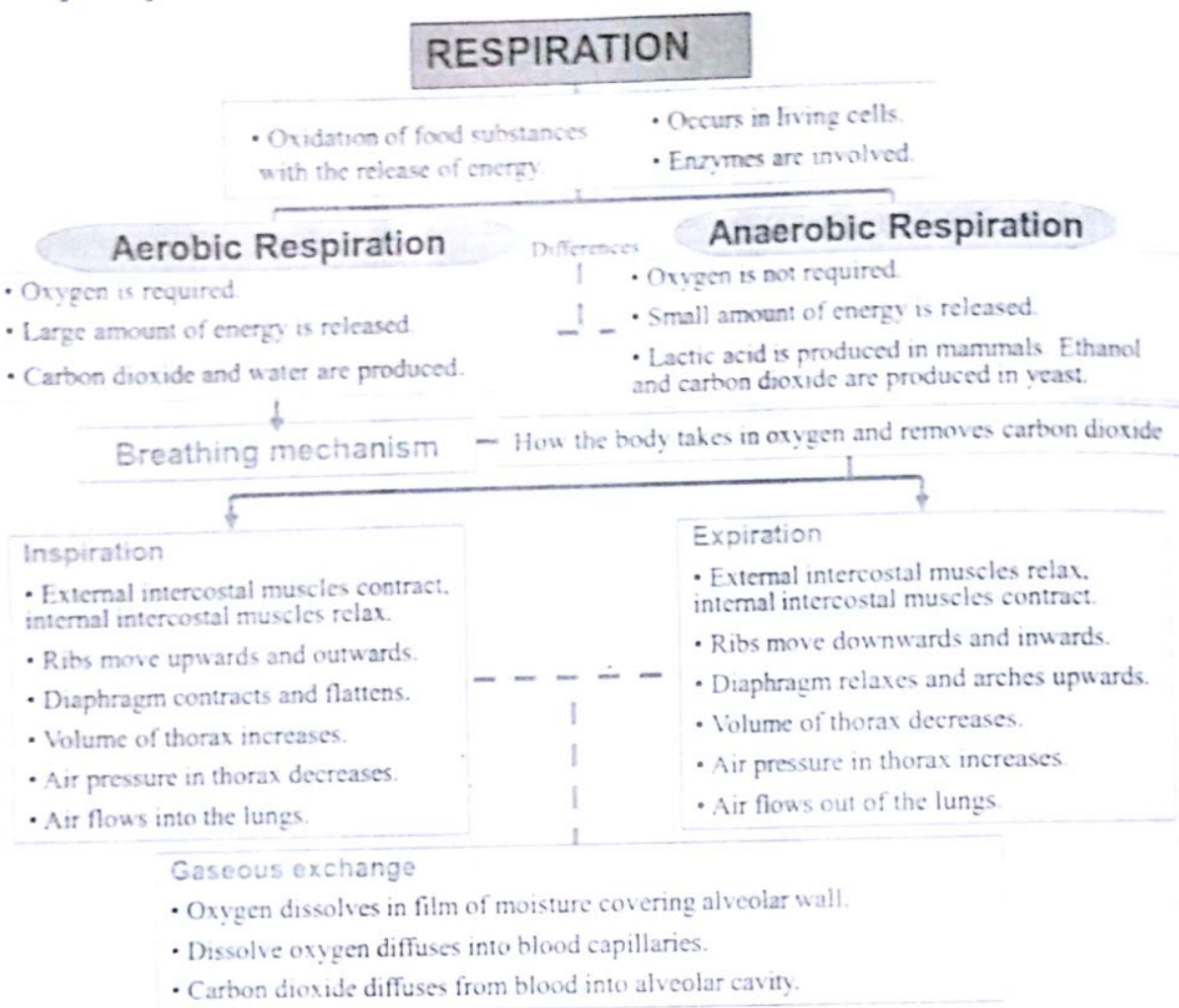
Emphysema is a condition often associated with chronic bronchitis. The walls of the alveoli become stretched and lose their elasticity. They do not empty properly, creating a build-up of carbon dioxide in the lungs. The patient suffers from breathlessness, and decreased efficiency of heart, brain etc. through too much carbon dioxide (and insufficient oxygen) in the blood.

Lung cancer

Cells in the lungs begin to divide uncontrollably, forming thickened tissues through which gases cannot pass, and which may block airways. Unless treated early, lung cancer is likely to be a fatal condition.

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Concept Map



For Books Order
0321-1100570

Syllabus Check List Respiration

After reading chapter are you able to:

- ☐ define respiration as the release of energy from food substances in all living cells
- ☐ define aerobic respiration as the release of a relatively large amount of energy by the breakdown of food substances in the presence of oxygen
- ☐ state the equation (in words or symbols) for aerobic respiration
- ☐ state the uses of energy in the human body: muscle contraction, protein synthesis, cell division, active transport, growth, the passage of nerve impulses and the maintenance of a constant body temperature
- ☐ define anaerobic respiration as the release of a relatively small amount of energy by the breakdown of food substances in the absence of oxygen
- ☐ state the equation (in words or symbols) for anaerobic respiration in humans and in yeast
- ☐ describe the effect of lactic acid production in muscles during exercise
- ☐ know the percentages of the gases in atmospheric air and investigate and state the differences between inspired and expired air
- ☐ investigate and state the effect of physical activity on rate and depth of breathing
- ☐ identify on diagrams and name the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries
- ☐ state the characteristics of, and describe the role of, the exchange surface of the alveoli in gas exchange
- ☐ describe the role of cilia, diaphragm, ribs and intercostal muscles (external and internal) in breathing.

O-LEVEL
BIOLOGY

Topic 9:
Excretion

NOTES BY

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Syllabus 2017 – 2019

Content

- 9.1 Structure and function of kidneys
- 9.2 Kidney dialysis

EXCRETION

The sum of all chemical reactions taking place in living cells are called as metabolic reactions and are always resulting certain waste products. These waste products are harmful if accumulated in body.

$$\text{Metabolism} = \text{Catabolism} + \text{Anabolism}$$

Excretion is define as the removal of toxic materials and waste products of metabolism from organism's body.

There are two main sets of excretory organs for removing metabolic waste products, the **lungs** and the **kidneys**.

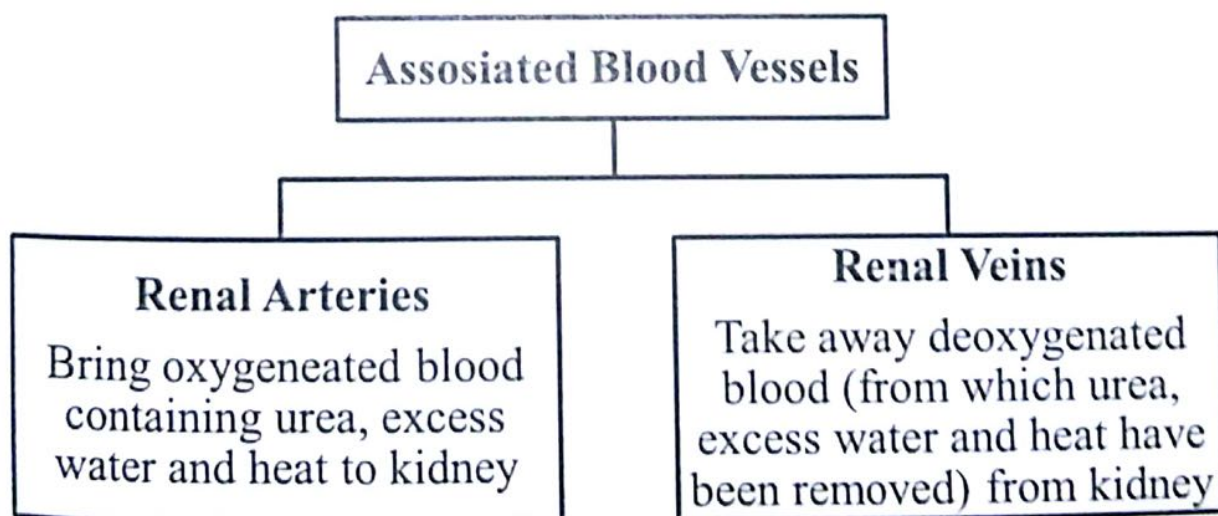
Excretory organ	Material removed	Method of removal
Lungs	carbon dioxide	breathing out (expiration or exhalation)
Kidneys	urea toxins	in urine in urine

Remember that:

- **Sweat glands** in the skin also remove small amounts of **urea**, as a constituent of sweat.
- The removal of **faeces** from the alimentary canal is **not** regarded as excretion, because the fibre which makes up the faeces is not the product of a chemical reaction in the body. Instead, it is passed all the way through the intestines unaffected by enzymes.
- The **pigment** which colours the faeces, which comes from the chemical breakdown of red blood cells, can be regarded as excretory.

The kidneys

The kidneys are two brown bean-shaped organs lying dorsally (i.e. towards the back) in the abdominal cavity. They are supplied with blood via the **renal artery**. Blood returns to the rest of the circulation by the **renal vein**.



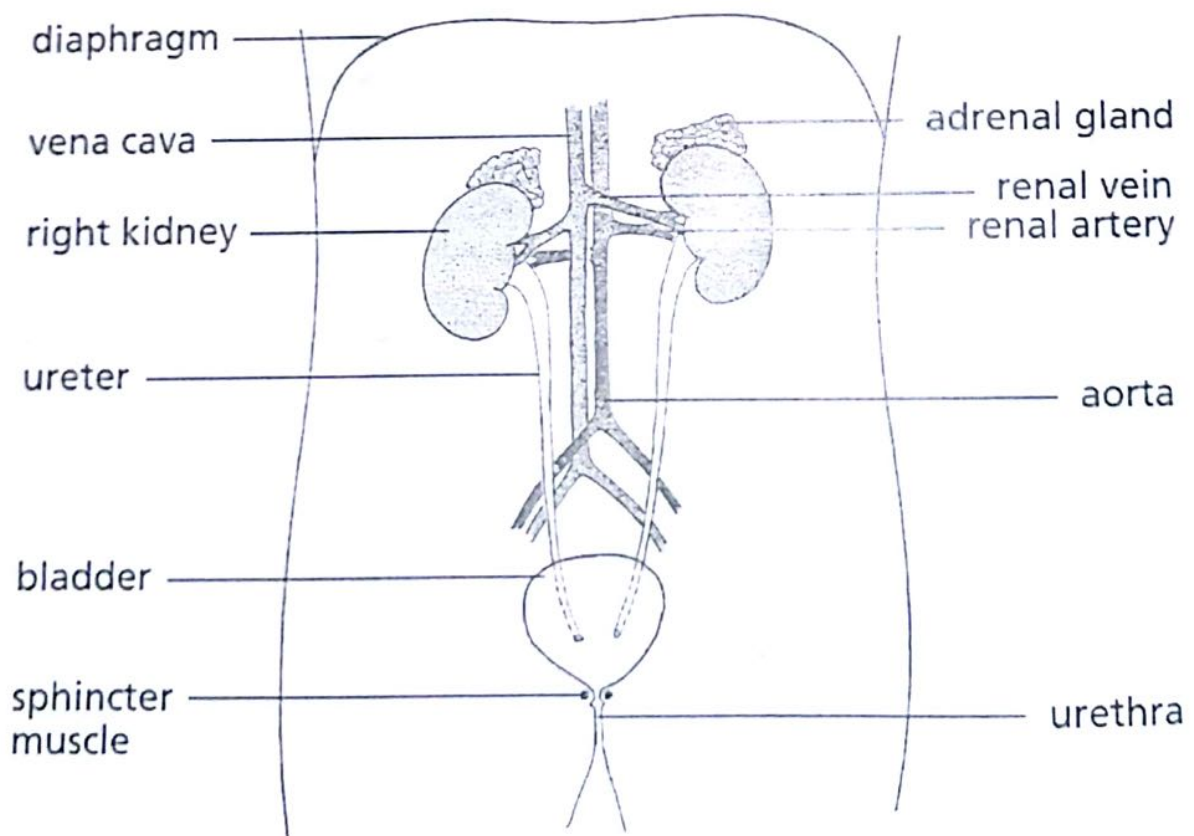
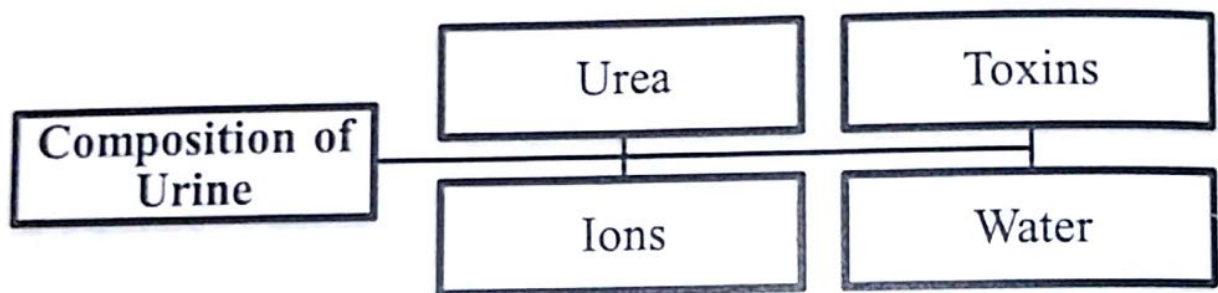
The kidneys contain a lot of **nephrons** and their role is to carry out **high pressure filtration** of the blood, during which **two functions** have to be achieved:

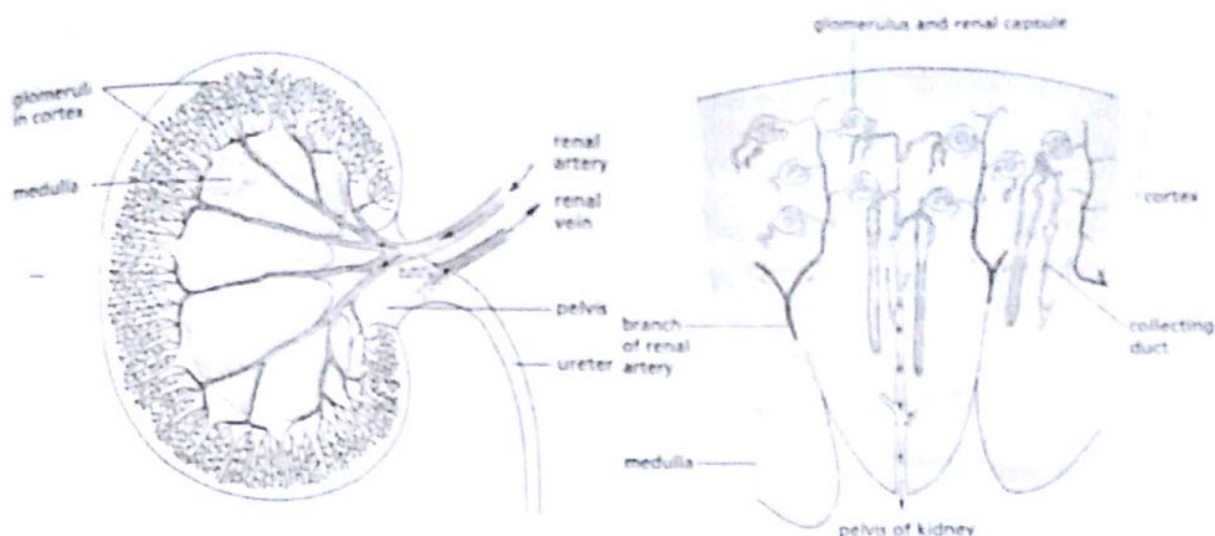
1. The removal of **urea** and **toxins** from the blood (i.e. part of **excretion**).
2. The maintenance of a **constant** concentration of blood plasma (i.e. part of **osmoregulation**).

Osmoregulation may be achieved either by the removal (if it is in excess) or the retention of **water**, or by the removal (if they are in excess) or the retention of **ions**, (salts).

If a diabetic person has an excess of glucose in their blood, the kidneys will remove some of the glucose as well.

The materials removed from the blood by each kidney are sent down the **ureter** (a narrow tube through which urine moves – **peristalsis**) to the **bladder** (a hollow muscular bag) where they are **stored** temporarily. Relaxation of the **bladder sphincter** muscle allows them to leave the body as a solution called urine via the **urethra** (a duct).



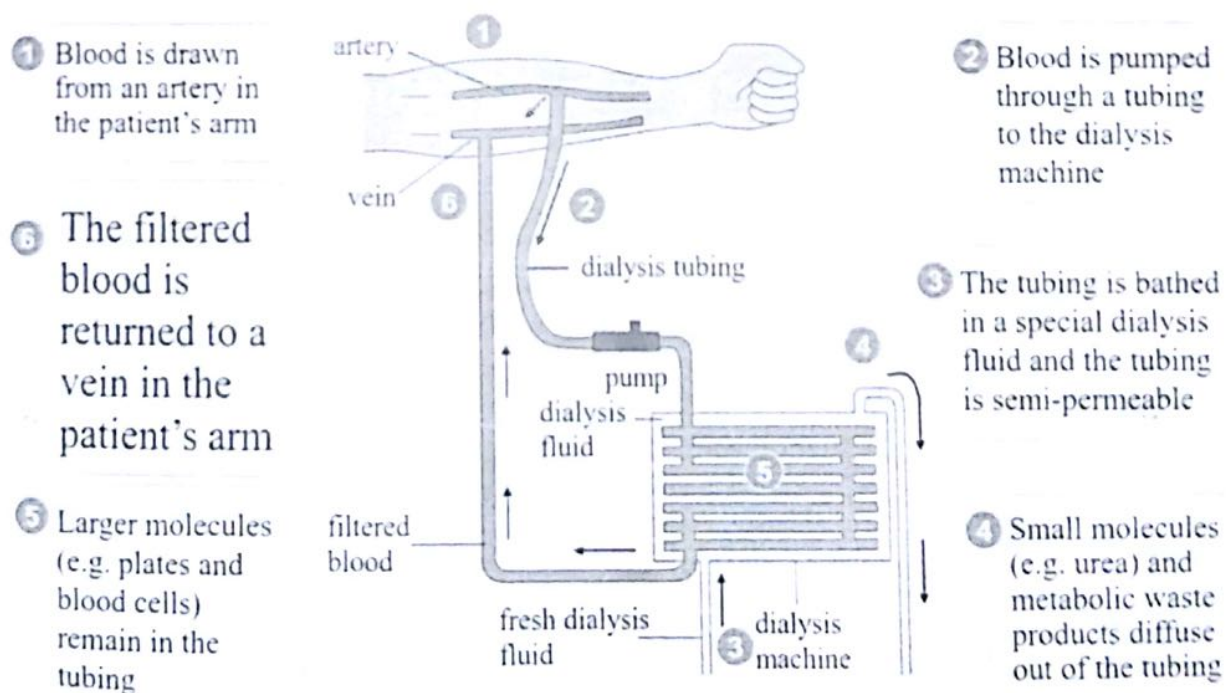


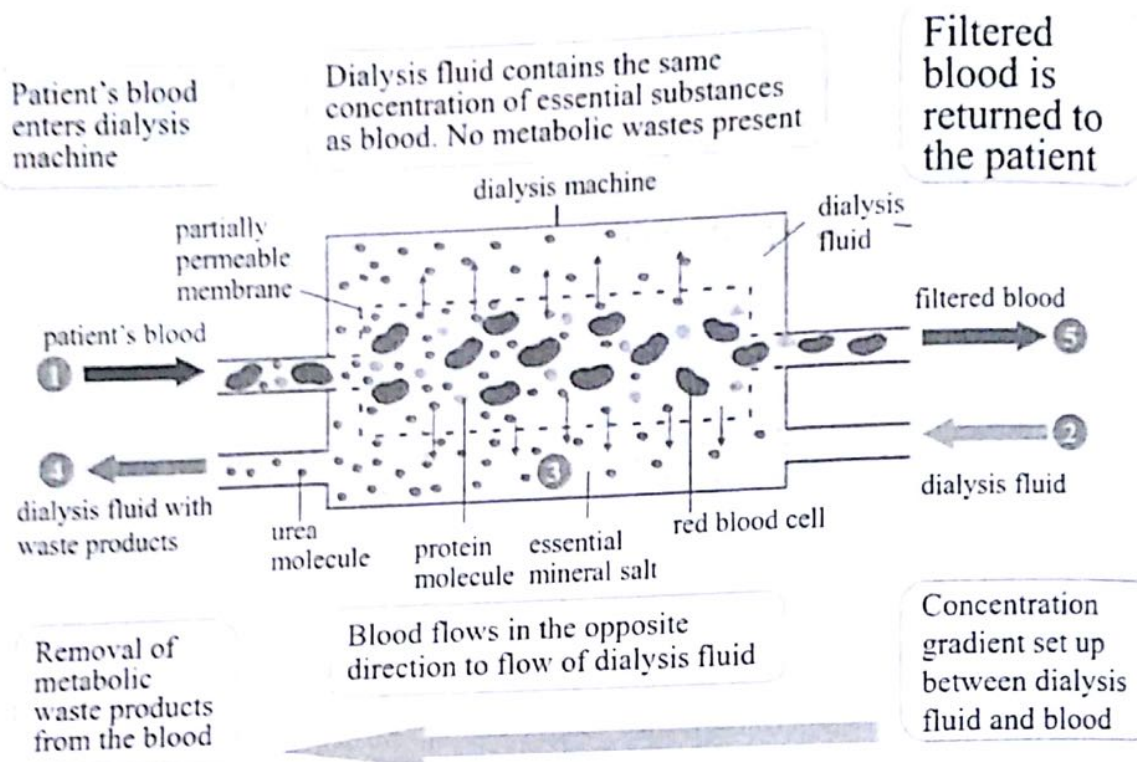
Kidney dialysis

If a person's kidneys stop working properly means fail to work, there will be a build-up of urea and toxins in their blood which will eventually prove fatal. A **kidney transplant** may be possible if a donor with a suitable tissue type is available. Otherwise, **kidney dialysis** may be used.

A **kidney dialysis machine** removes chemicals with **small** molecules (urea, toxins and ions) from a patient's blood, but does not allow larger molecules (such as plasma proteins) to leave the blood.

The blood is passed through **dialysis tubing**, which is placed in a **bathing or washing fluid**. Only the small molecules in the blood can pass from the tubing into the fluid. The fluid is continuously renewed, and washes away the substances removed from the blood. By varying the concentration of substances in the washing fluid, the amounts of those substances which leave the blood can be controlled. The concentration of plasma in the blood can also be controlled in this way. The dialysed blood is then returned to the patient.





For Books Order
0321-1100570

Syllabus Check List Excretion

After reading chapter are you able to:

- ☐ define excretion as the removal of toxic materials and the waste products of metabolism from organisms
- ☐ describe the removal of carbon dioxide from the lungs
- ☐ identify on diagrams and name the kidneys, ureters, bladder, urethra and state the function of each (the function of the kidney should be described simply as removing urea and excess salts and water from the blood; details of kidney structure and nephron are **not** required)
- ☐ describe dialysis in kidney machines as the diffusion of waste products and salts (small molecules) through a membrane; large molecules (e.g. protein) remain in the blood.

Syllabus 2017 – 2019

Content

- 10.1 Structure and function of the skin

O-LEVEL

BIOLOGY

Topic 10: Homeostasis

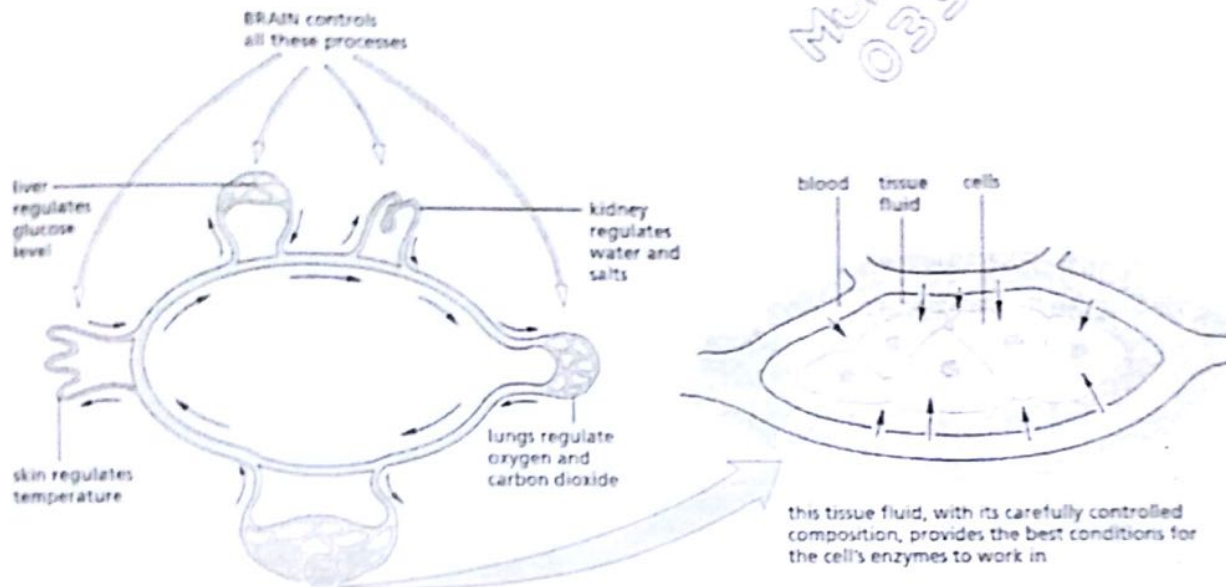
NOTES BY

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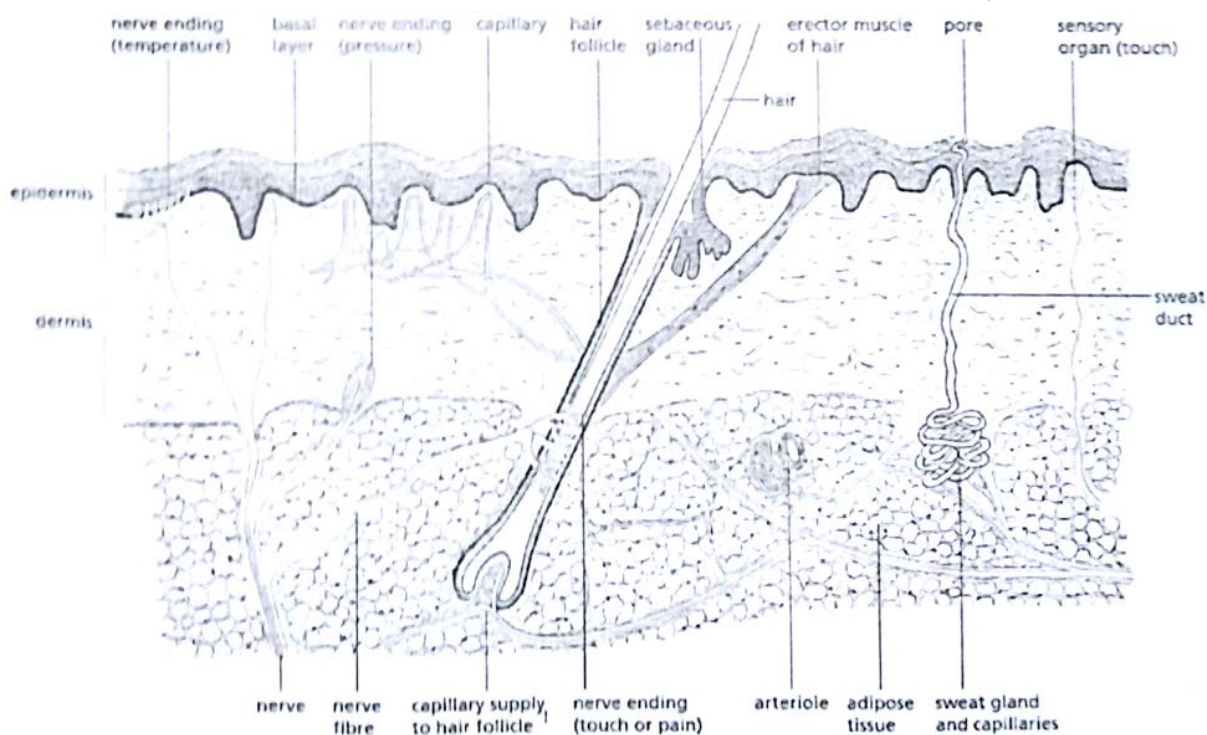
HOMEOSTASIS

The body will operate most efficiently when conditions within it remain reasonably stable. As has been shown, the kidneys have the important function of keeping the blood plasma at a constant concentration. The tissue fluid bathing the body's cells is therefore always at a constant concentration. Because cell membranes are partially permeable, osmosis will ensure that the concentration within all cells remains constant as well. Many organs within the body play a part in maintaining constant conditions. They are described as **organs of homeostasis**. So overall **Homeostasis** is defined as the maintenance of a constant internal environment.



The skin

The skin is the largest organ of the human body. It is an important **sense organ** but also forms the barriers between the body and the external environment. It is the organ through which we may both gain and lose heat. This is particularly important in the **homeostatic** process of **temperature regulation**.



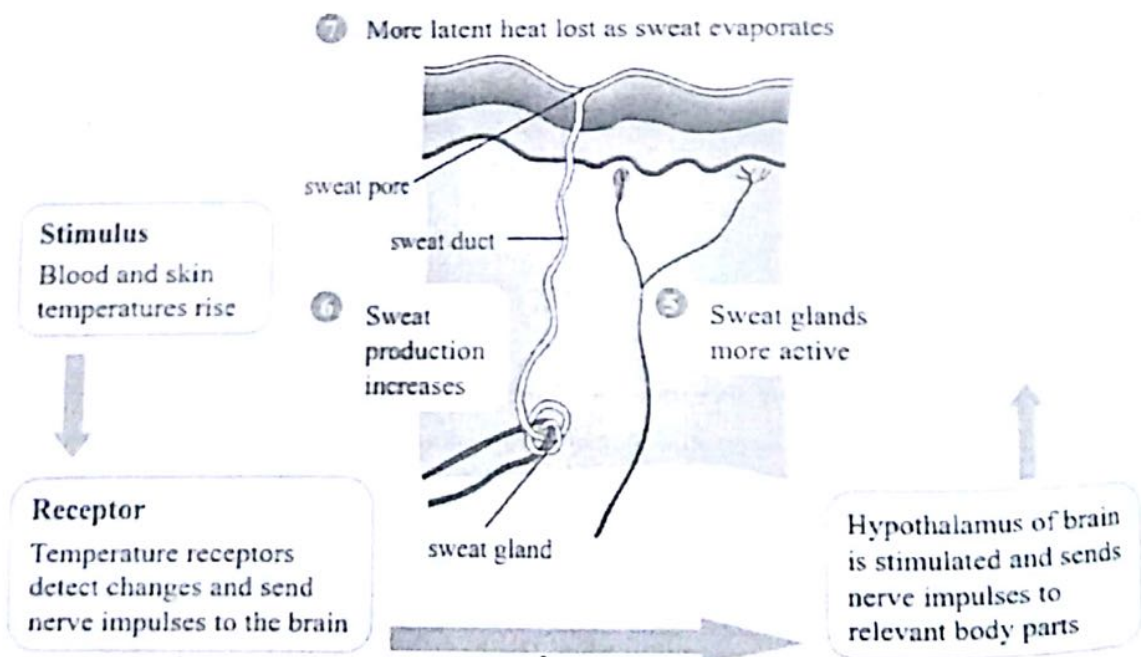
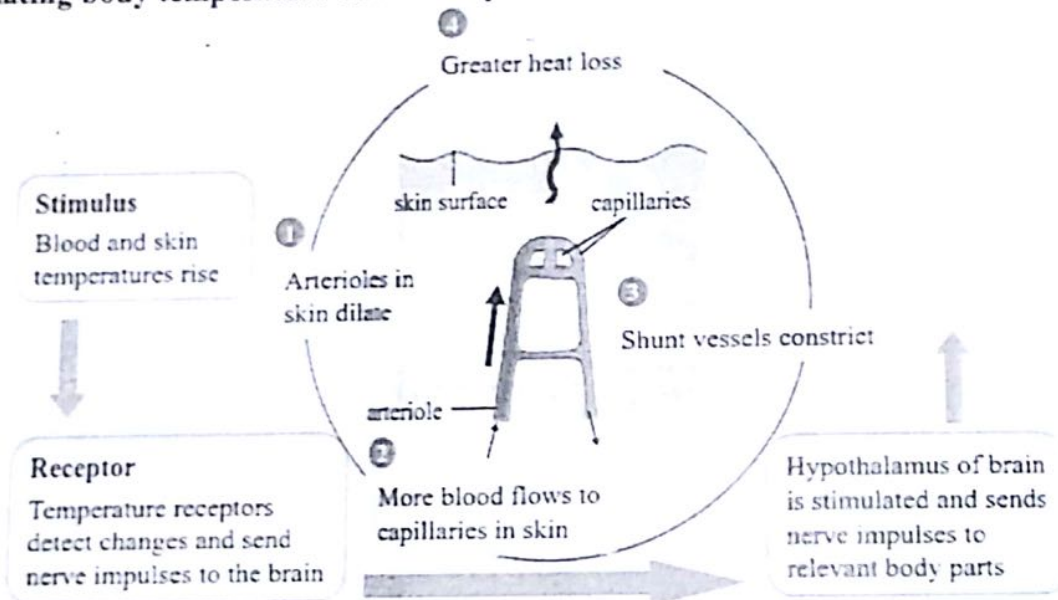
The part played by the skin in temperature regulation

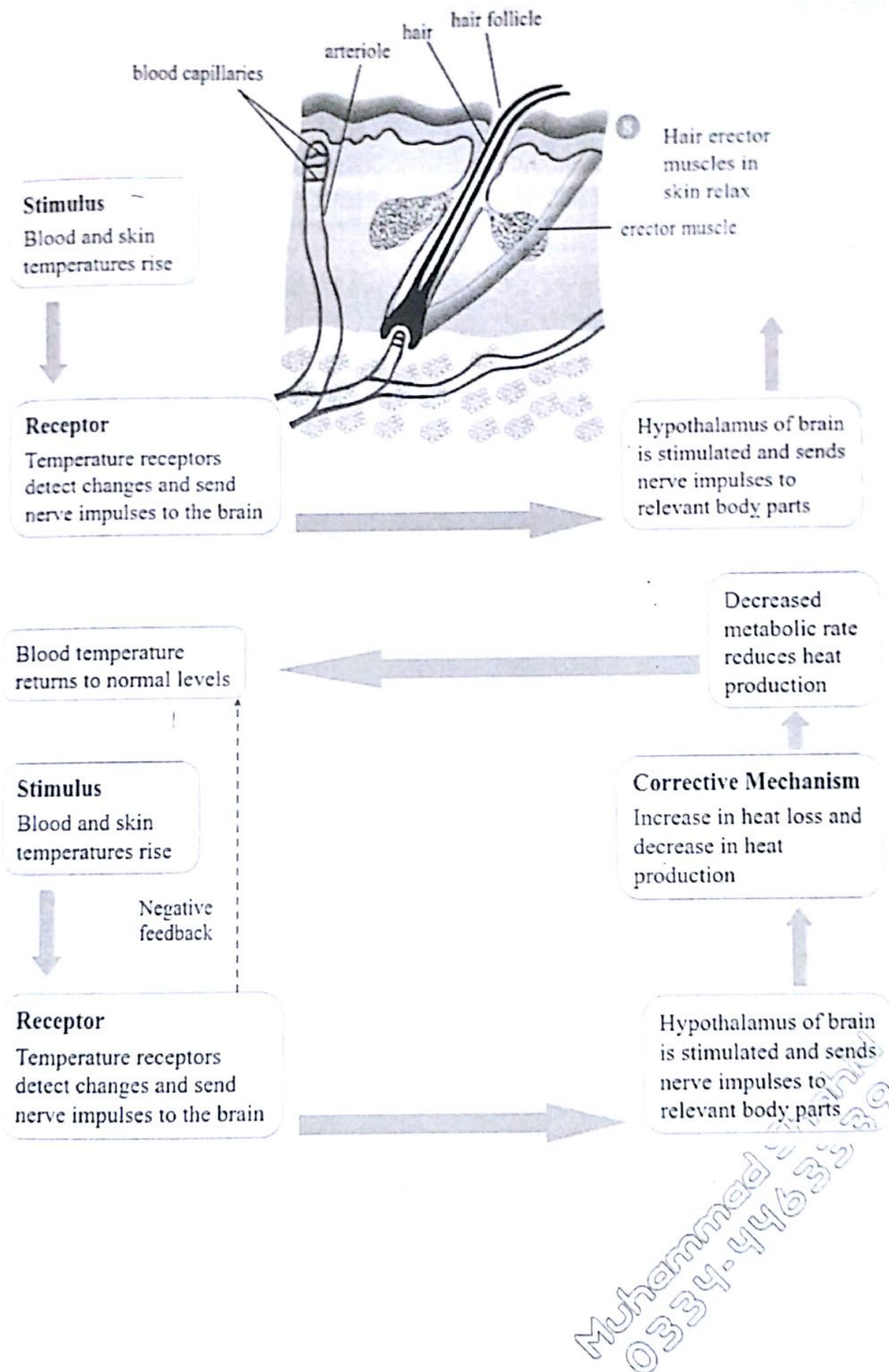
When the temperature of the blood rises above 37°C	When the temperature of the blood falls below 37°C
The sweat glands release more sweat. The sweat evaporates.*	Sweating is greatly reduced.*
Arterioles in the skin dilate (become wider as their muscular walls relax).	Arterioles in the skin constrict (become narrower as their muscular walls contract).
More blood is brought to the skin – blood carries that.*	Less blood flows beneath the skin.*
	Fat in the DERMIS of the skin acts as an insulator.*

* More heat is lost to the environment, cooling the blood, and allowing the body temperature to return to normal. (Note: The person may also take cold drinks and seek shade.)

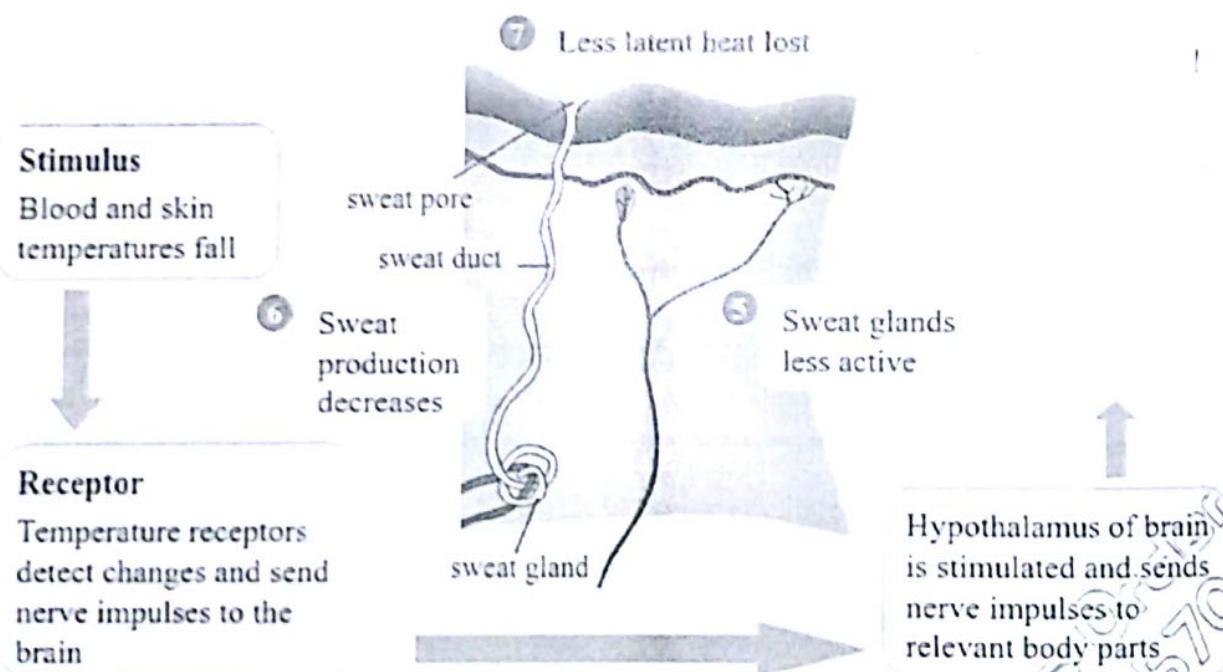
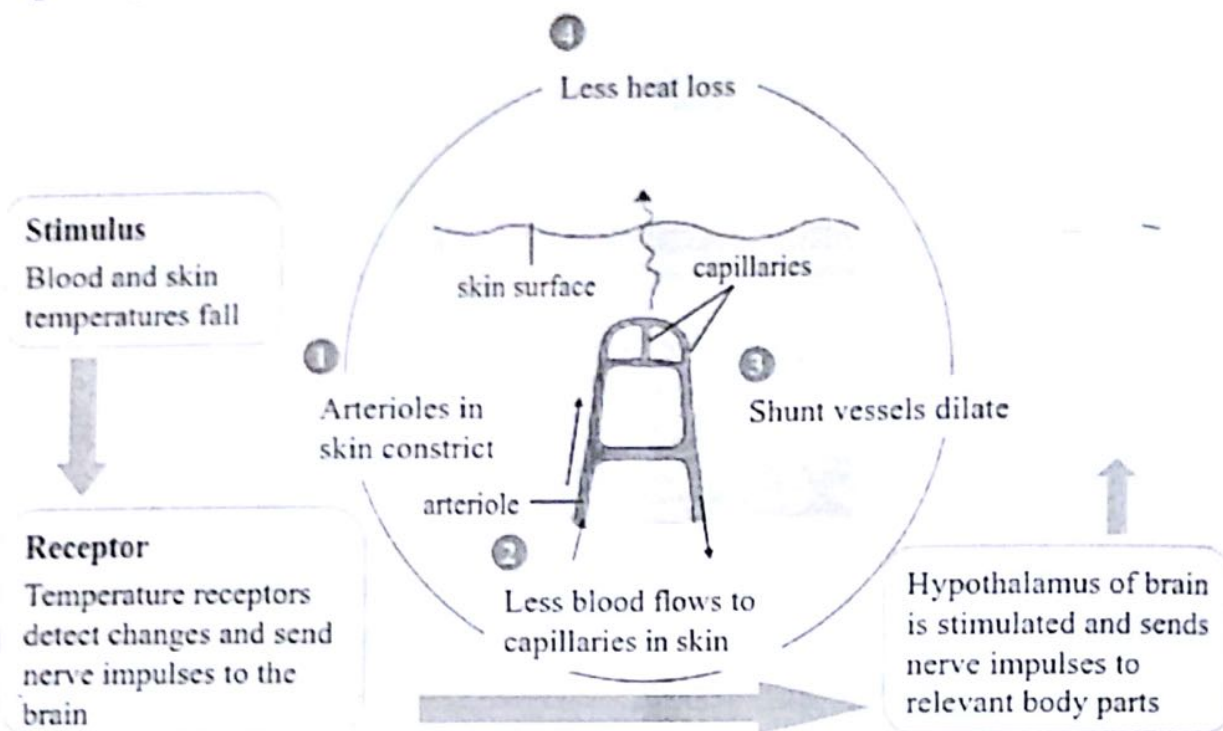
* Less heat is lost to the environment, allowing metabolic processes to release energy in the form of heat to help bring the body temperature back to normal.

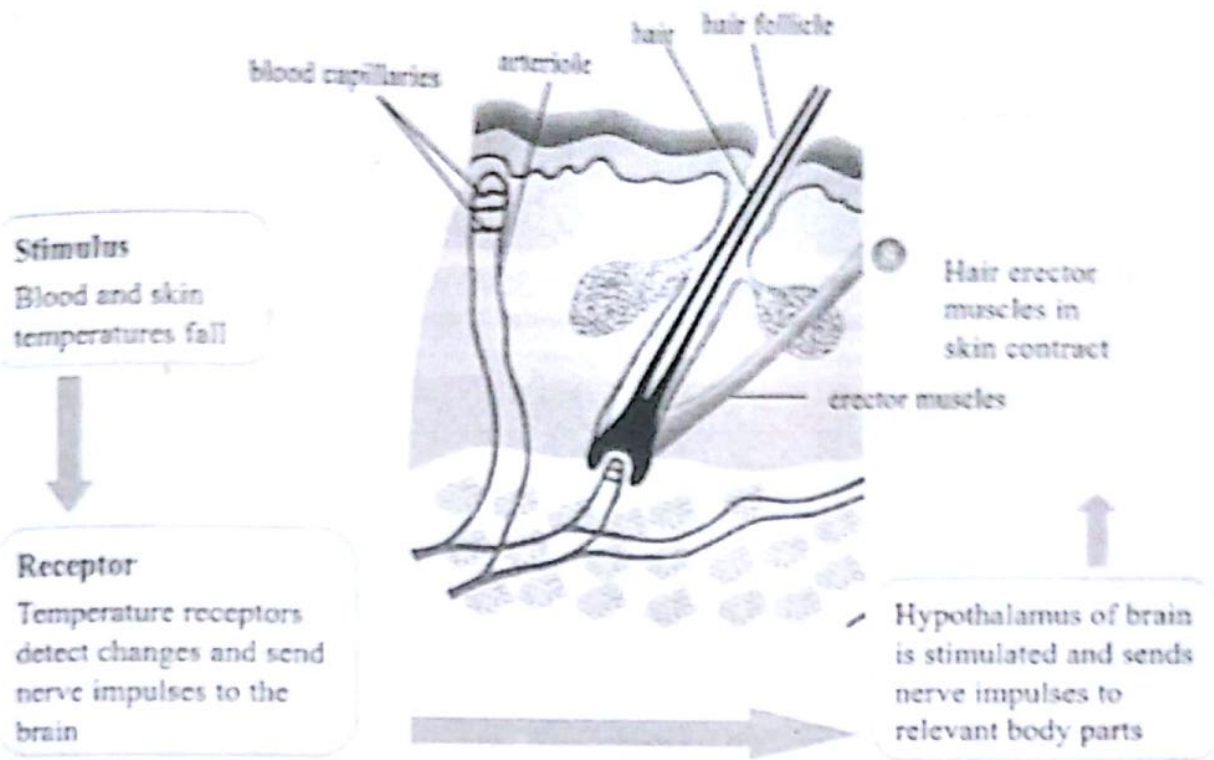
Regulating body temperature on a hot day





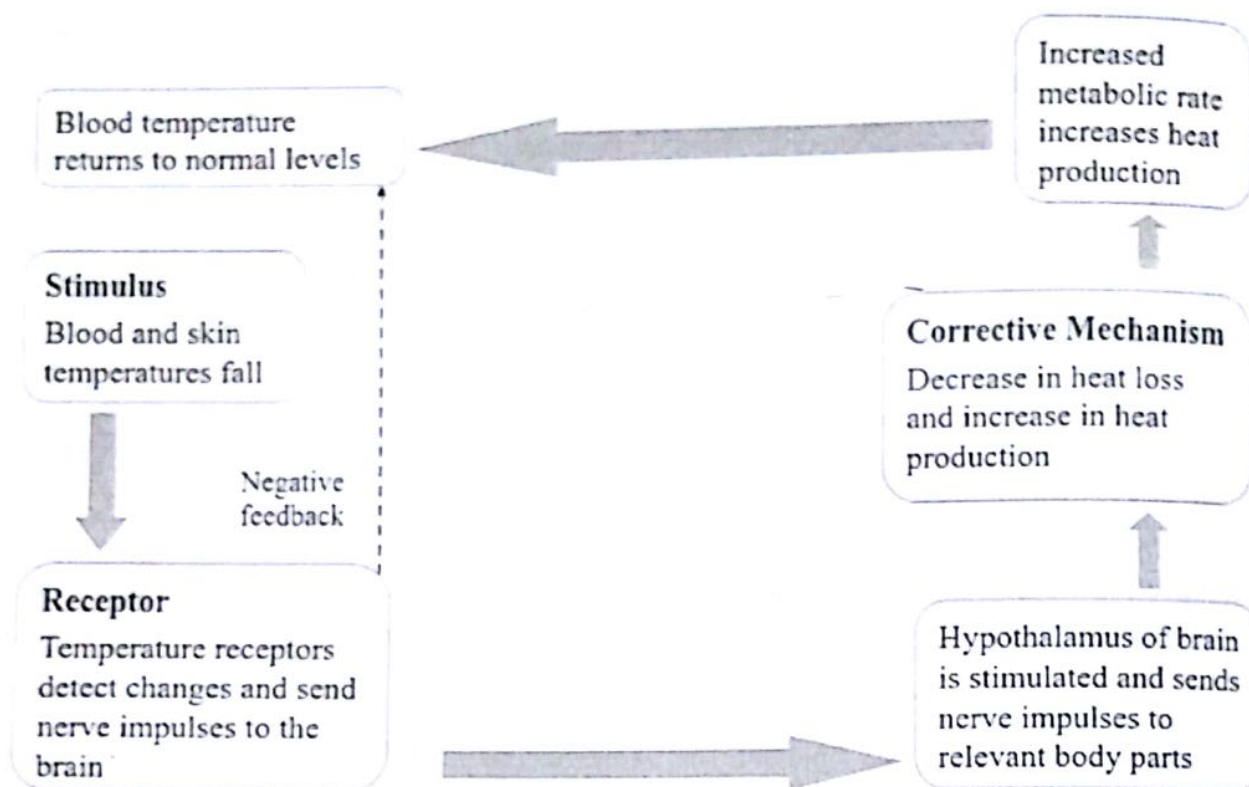
Regulating body temperature on a cold day





Shivering occurs when insufficient heat is produced





Shivering

If the temperature of the blood falls below 37°C and the measures outlined above are inadequate, muscles in the body will start to contract and relax rhythmically, which releases heat energy. This reaction is called **shivering**.

To help raise their body temperature, a person may take warm drinks, increase the insulating layer of air around their body by wearing more clothes, and do some exercise.

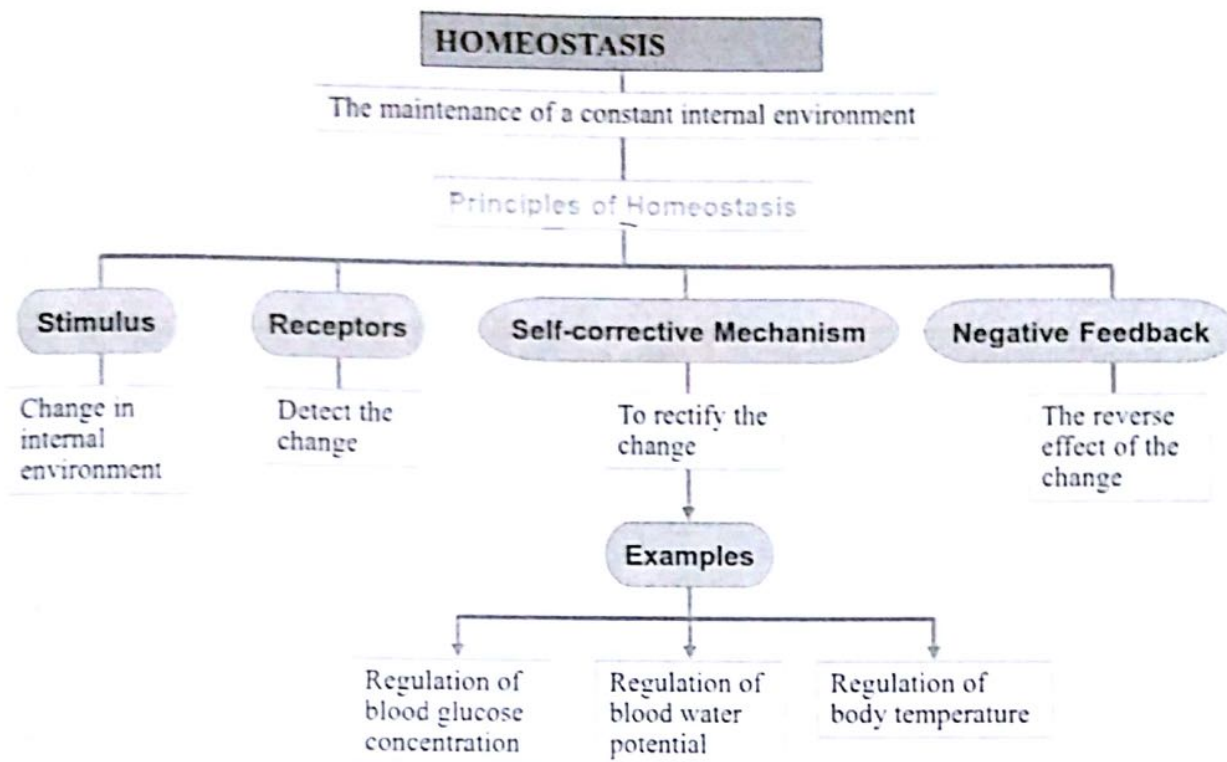
Temperature receptors in the skin

As a sense organ, one of the properties of the skin is to be able to detect **temperature change in the external environment**. A change in atmospheric temperature will be detected by temperature receptors on the skin. These will start some of the temperature control mechanisms even before there is any significant change in the temperature of the blood.

Changes in the blood temperature are detected by the **Hypothalamus** situated on the underside of the **brain**. This is the structure responsible for the **coordination** of all temperature control mechanisms.

For Books Order
0321-1100570

Concept Map



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Syllabus Check List Homeostasis

After reading chapter are you able to:

- ☐ define homeostasis as the maintenance of a constant internal environment
- ☐ explain the concept of control by negative feedback
- ☐ identify, on a diagram of the skin, hairs, sweat glands, temperature receptors, blood vessels and fatty tissue
- ☐ describe the maintenance of a constant body temperature in humans in terms of insulation and the role of temperature receptors in the skin, sweating, shivering, blood vessels near the skin surface and the coordinating role of the brain.

Syllabus 2017 – 2019**Content**

- 11.1 Nervous system
- 11.2 Receptors
- 11.3 Reflex action
- 11.4 Hormones

O-LEVEL**BIOLOGY**

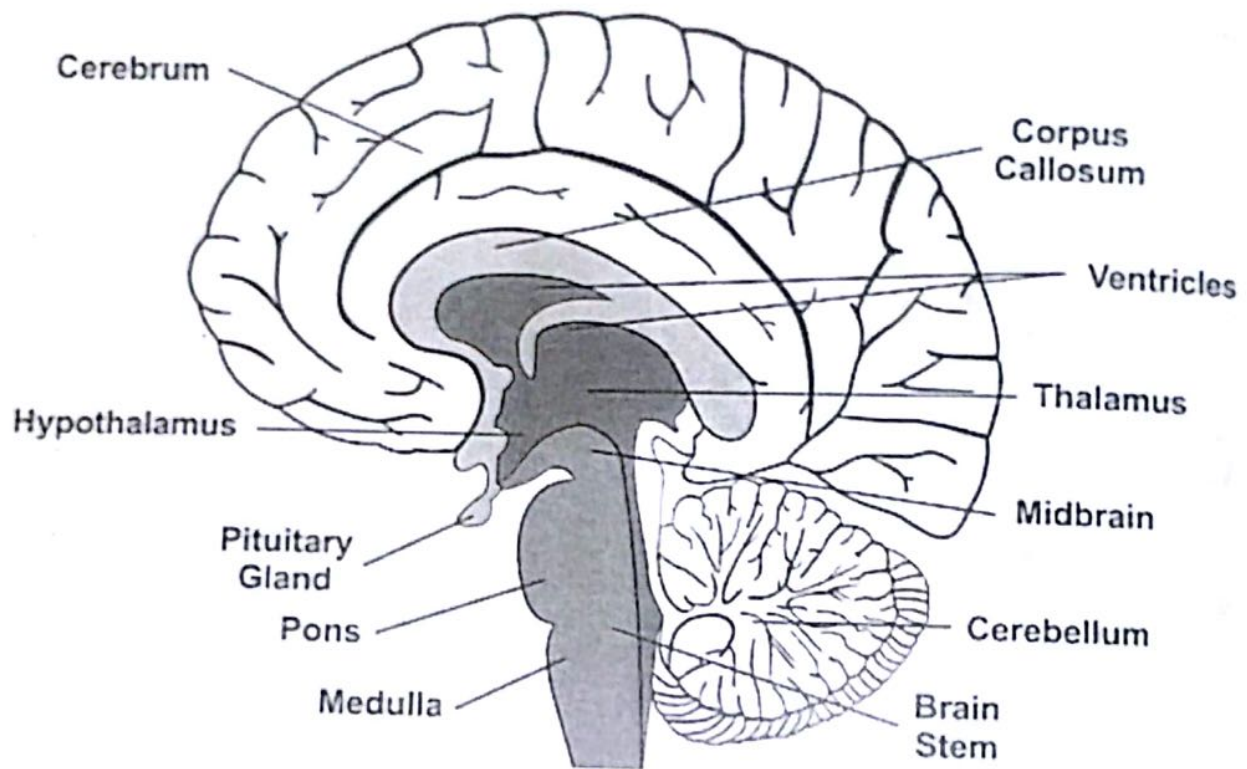
Topic 11: Coordination and Response

NOTES BY

MUHAMMAD SHAHID**Cell: 0334-4463339**

COORDINATION AND RESPONSE

The various organs of body must work in coordination if an organism is to survive effectively in its environment. To achieve this, the body has a series of **receptors** which pass information about the environment to a **coordinating centre** called the (**central nervous system – CNS**). CNS is made up of the **brain** and **spinal cord**, and a system of **nerves**. Nerves carry impulses between receptor organs (e.g. the eyes), the CNS, and effectors (muscles or glands). The most highly developed part of the CNS is the **brain**.



The functions of the major parts of the brain are described as below:

Cerebrum

The cerebrum is in the form of two matching halves – known as the cerebral hemispheres – and is responsible for:

- **memory**
- **sight**
- **coordination** of the organs of the body
- **control of voluntary** actions
- the reception of **sensation**.

Cerebellum

The cerebellum is the region of **balance** and **instinct**.

Medulla

The medulla joins the brain to the spinal cord. It controls **unconscious** activities such as **heartbeat**, **peristalsis** and **breathing**.

Hypothalamus

The **hypothalamus** lies under the cerebrum and is the part of the brain responsible for **monitoring changes**, particularly in the blood. It may be regarded as the '**homeostat**' of the body.

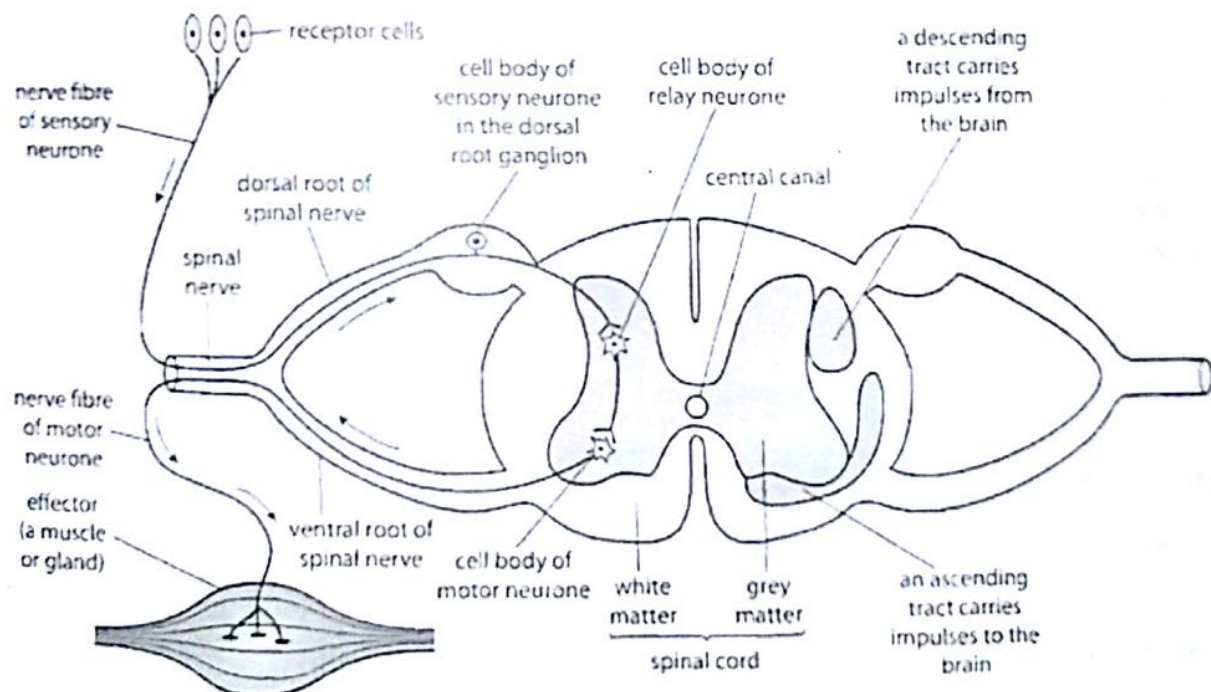
Pituitary gland

Situated beneath the hypothalamus, the pituitary gland is made up partly of nerve tissue. It is sometimes called the '**master gland**' because it manufactures chemicals called **hormones** and releases them into the blood. These hormones control the activity of many glands and other organs throughout the body, such as those responsible for **growth** (e.g. of bones) and **development** (e.g. sexual development). Therefore, the pituitary gland has a very important part to play in **coordination**. It is regularly 'instructed' by the hypothalamus.

Spinal cord

In the same way that a series of nerves (**cranial nerves**) serve the brain, impulses are relayed to, and conducted from the spinal cord by nerves called **spinal nerves**. Spinal nerves are connected with receptors and effectors in parts of the body other than the head.

In emergency situations, the spinal cord can receive and transmit impulses to bring about rapid, often protective responses called **reflex actions**. The **central** region of the spinal cord (the **grey matter**) contains nerve cells (**relay neurones**) involved solely in this process. The outer region of the spinal cord (the **white matter**) contains nerve cells involved in either supplying sensory information to the brain, or passing impulses on to muscles which are instructed by the brain (i.e. voluntary actions).



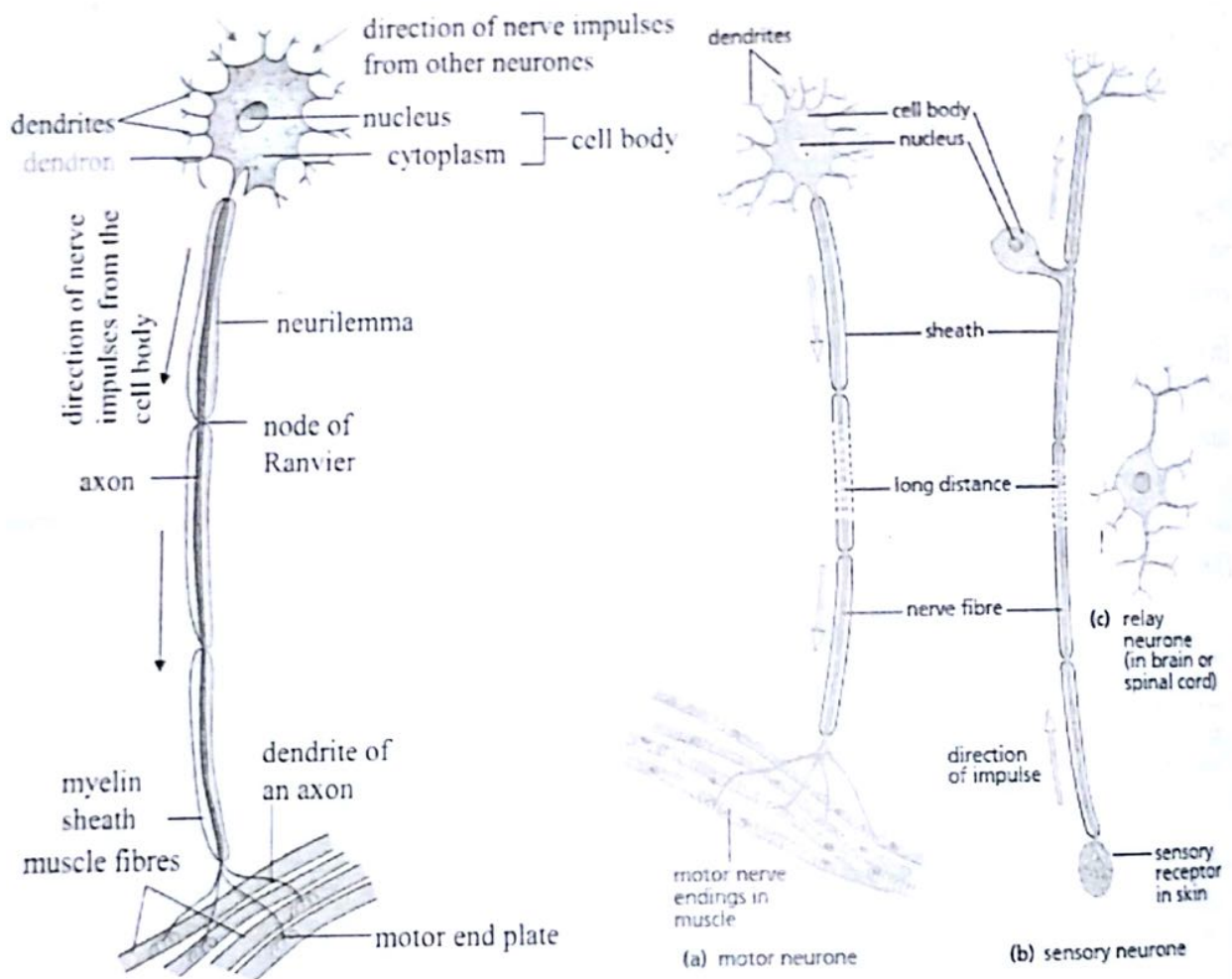
Nerves

A nerve is like a communication cable which contains a large number of small 'wires' called **neurones**. Each neurone is an individual **nerve cell** with its own cytoplasm, cell membrane and nucleus.

Neurones which conduct impulses from sensory receptors to the brain or spinal cord are called **sensory neurones**.

Neurones which then direct those impulses either to other parts of the brain or to other parts of the spinal cord are called **relay neurones**.

Neurones are **insulated** by a fatty ('myelin') sheath. They are **long**, they **target the exact** area to be affected and they conduct their impulses very **quickly**. These features are **vital** if an action is to be taken very quickly to prevent damage, as in a **reflex action**.

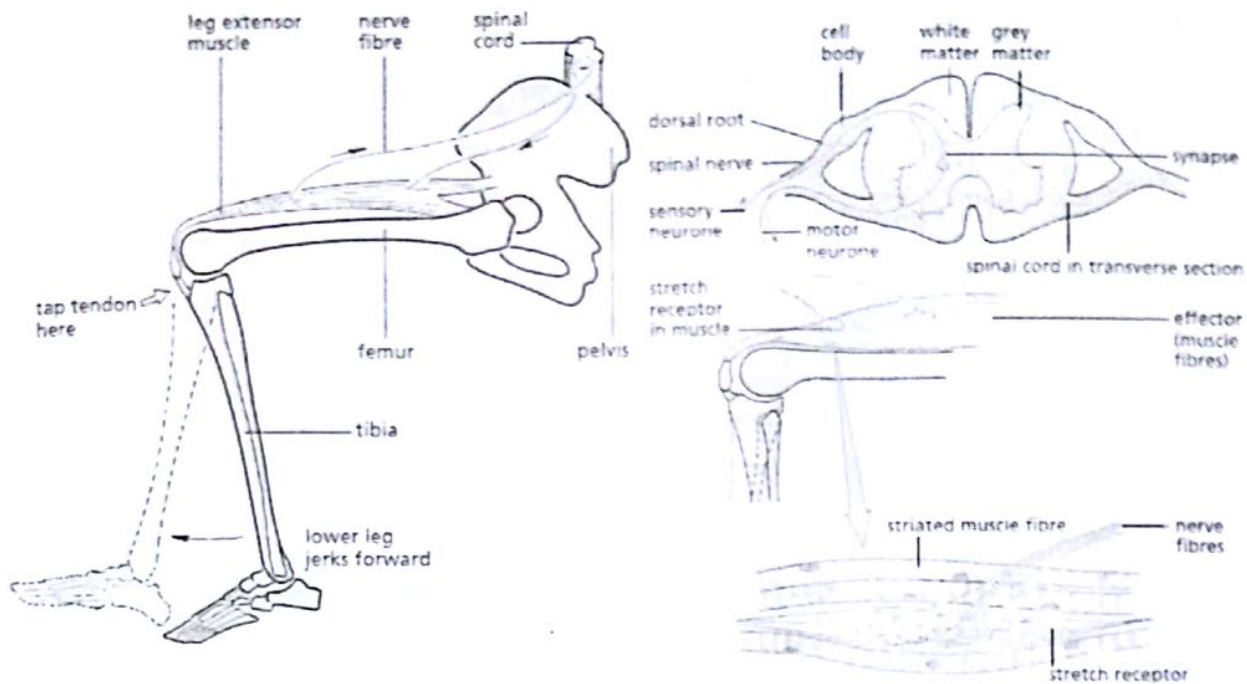


Reflex action

A reflex action is a coordinated response to a specific stimulus.

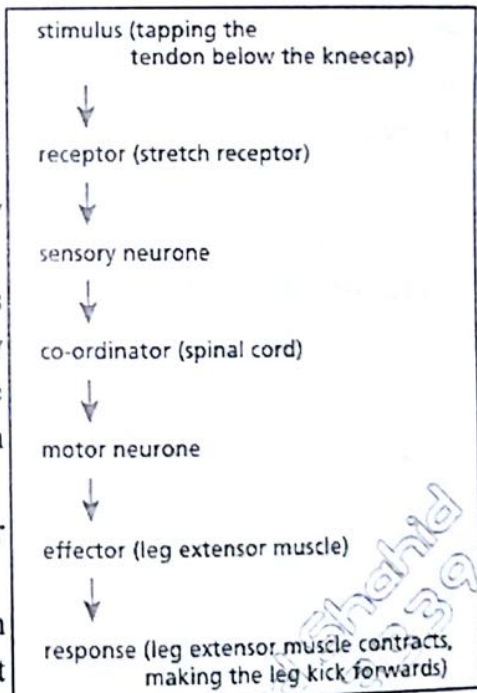
In the example of the iris reflex, the brain is the part of the CNS involved, and the reflex action is called a **cranial reflex**.

When the spinal cord **alone** directs the response, the action is described as a **spinal reflex**. For example, when we quickly remove our finger from a hot object and leg kick off when knee tendon is knocked.

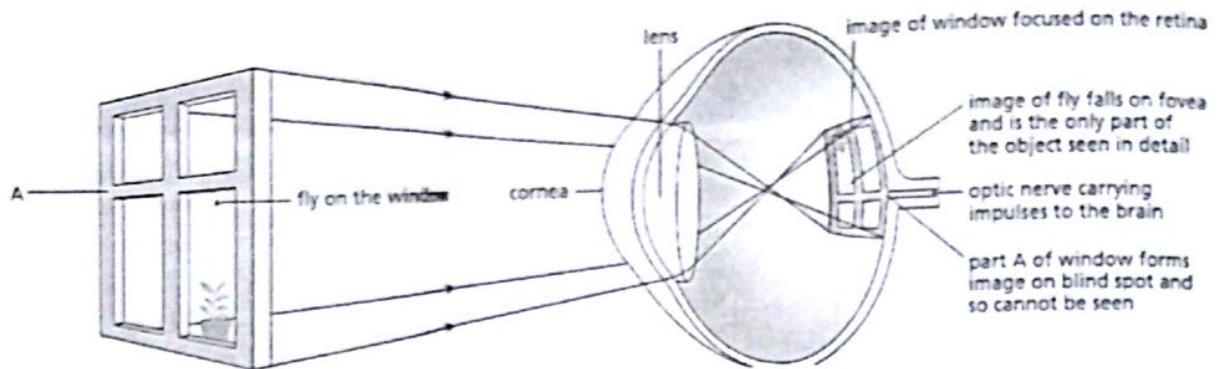


The sequence of events in a spinal reflex is:

1. A **stimulus** is received by the **sensory receptor**.
2. An **impulse** is generated and carried by **sensory neurones** towards the spinal cord.
3. The sensory neurones become part of a **spinal nerve**.
4. The impulse travels toward the spinal cord along the **dorsal root**. The dorsal root is part of the linking pathway between outside stimuli and the spinal nerve.
5. Impulses arrive at the nerve endings of the sensory neurone in the **grey matter** of the spinal cord.
6. The nerve endings release a **chemical** which **diffuses** across a gap – the **synapse** – between the sensory neurone and the nerve endings of a relay neurone. The chemical stimulates the **relay neurone** to produce an impulse.
7. Another synapse links the relay neurone with a **motor neurone**.
8. The impulse travels along motor neurones away from the spinal cord along the **ventral root**. The ventral root is part of the linking pathway between the spinal nerve and the effector.
9. The nerve endings of the motor neurone are applied to the **effector** (the biceps muscle in this case).
10. A **response** is produced (as the biceps muscle contract to lift the hand clear of the stimulus).



but are not usually aware of them. Each eye records a different part of our field of view and covers the blind spot of the other.

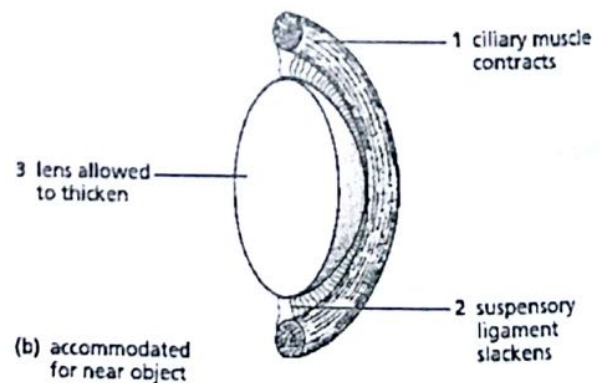
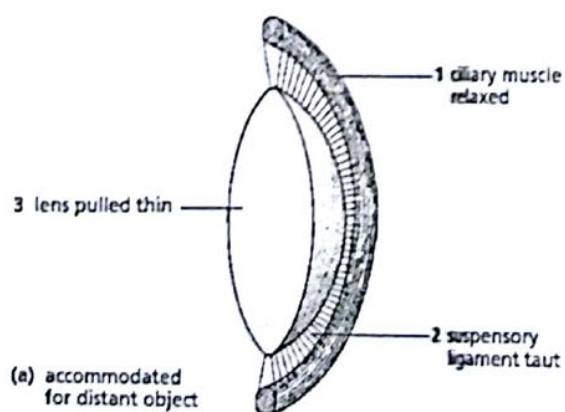


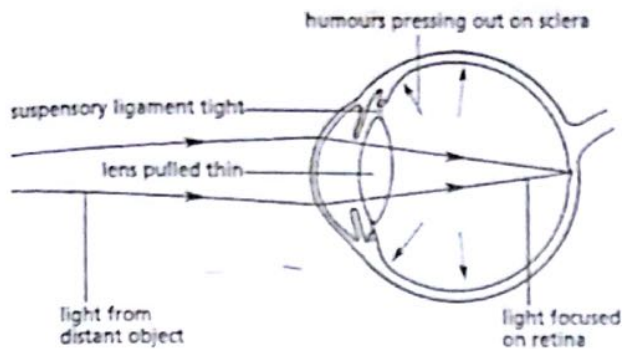
Accommodation

The ability of the lens to change shape and focus on objects at different distances is called **accommodation**. This ability depends on three factors:

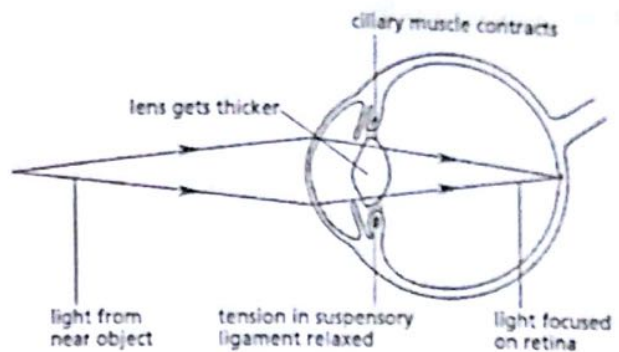
- the **elasticity** of the lens
- the existence of **ciliary muscles** which are used to alter the shape of the lens
- the **suspensory ligaments** which transfer the effect of the ciliary muscles to the lens.

When viewing a near object	When viewing a distant object
The (circular) ciliary muscles contract , reducing their circumference.	The (circular) ciliary muscles relax , increasing their circumference.
They reduce pull on the (elastic) suspensory ligaments .	The suspensory ligaments are pulled tight.
With less force on the lens, its elasticity allows it to become wider (' bulge ') – decreasing its focal length.	The lens is stretched to become longer and thinner, increasing its focal length.
Rays from the near object produce a focused image on the retina.	Rays from the distant object are brought to focus on the retina.





(a) accommodated for distant object



(b) accommodated for near object

The value of having two eyes

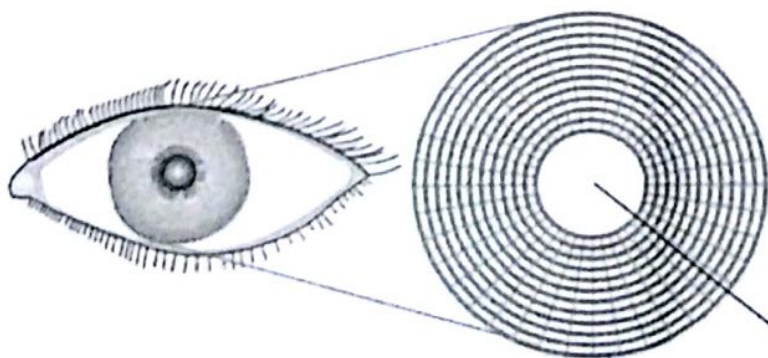
Apart from overcoming the effect of the blind spot, two eyes view the same picture from two slightly different positions. This provides vision in **three dimensions**, the ability to **judge distance** (and therefore speed), and offers animals a chance of survival even if one eye is damaged.

The 'pupil' (or iris) reflex

Bright light could seriously damage the delicate light-sensitive cells of the retina. The intensity of light falling on the retina is therefore controlled by the IRIS. It has an **antagonistic** arrangement of **circular** and **radial** muscles.

In dim light	In bright light
Light-sensitive cells in the retina detect the light intensity.	Light-sensitive cells in the retina detect the light intensity.
Impulses are sent along the optic (a sensory) nerve to the brain.	Impulses are sent along the optic (a sensory) nerve to the brain.
The brain returns impulses along a motor nerve to the radial muscles of the iris.	The brain returns impulses along a motor nerve to the circular muscles of the iris.
The radial iris muscles contract while the circular iris muscles relax.	The circular iris muscles contract while radial iris muscles relax.
The diameter of the pupil increases, allowing more light to enter.	The diameter of the pupil (the hole in the centre) decreases, allowing less light to enter, decreasing the risk of damage to the retina.

Pupil in bright Light

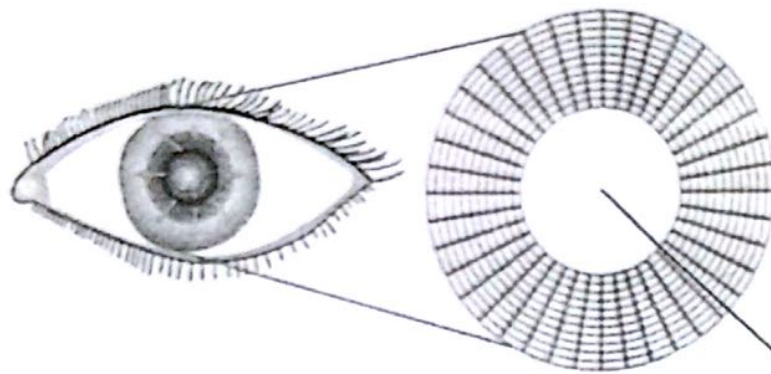


① Circular muscles of the iris contract

② Radial muscles of the iris relax

③ Pupil constricts and this reduces the amount of light entering the eye

Pupil in dim Light



① Radial muscles of the iris contract

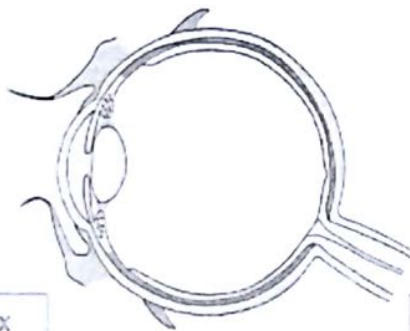


② Circular muscles of the iris relax



③ Pupil dilates and this increases the amount of light entering the eye

Concept Map of Human Eye



Pupil Reflex

In bright light

- Circular muscles in iris contract.
- Radial muscles relax.
- Pupil becomes smaller, hence less light enters the eye

In dim light

- Radial muscles in iris contract.
- Circular muscles in iris relax.
- Pupil enlarges, hence more light enters the eye

Focusing

Distant object (7 metres or more)

- Ciliary muscles relax
- Suspensory ligament become taut
- Lens becomes thinner and less convex

Near object

- Ciliary muscles contract
- Suspensory ligaments slacken
- Lens becomes thicker and more convex

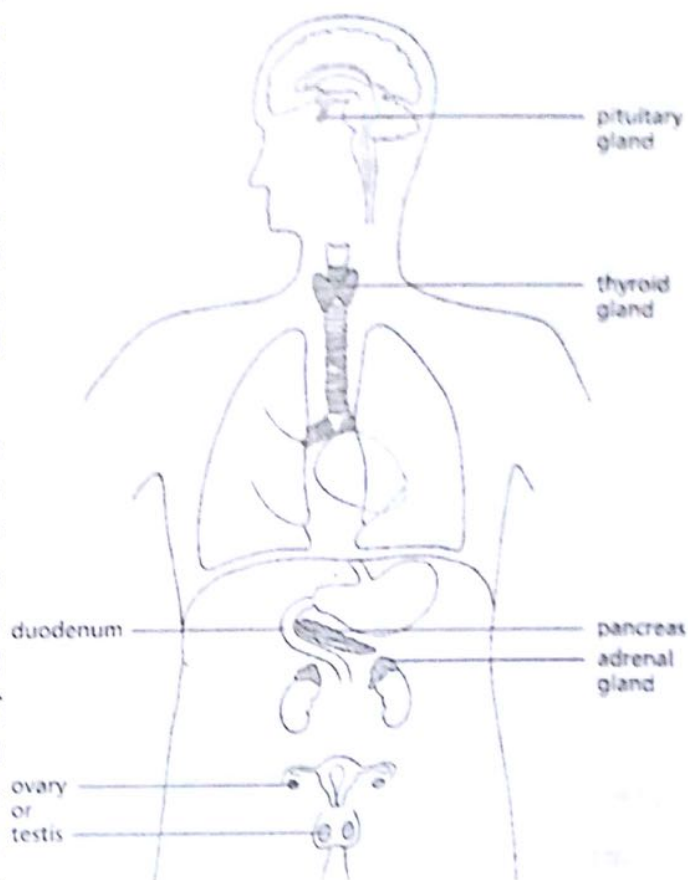
For Books 0321-1100570

Chemical coordination in human beings

Hormones

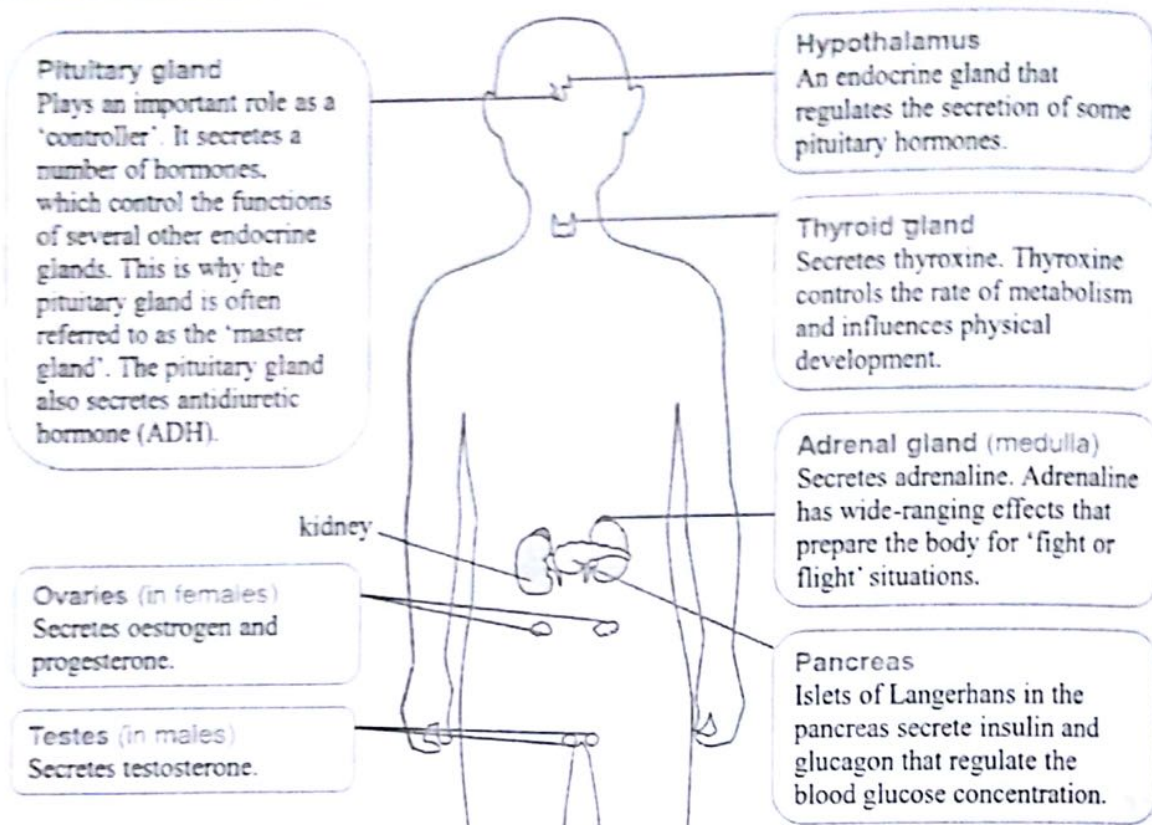
A hormone is a chemical substance, produced by a gland and carried by the blood, which alters the activity of one or more specific target organs. It is then destroyed in the liver. Hormone molecules must be relatively **small**, **soluble** and **diffuse easily**, so they can pass quickly from the cells that make them, into (and, later, out of) blood capillaries.

The **endocrine** glands that produce hormones have no ducts (small tubes) to carry the hormones away. Instead, they pass their hormones directly into the blood. These glands are therefore described as **ductless**. The **adrenal glands** and the **pancreas** are examples of endocrine glands. **Remember!** Special cells in the **Islets of Langerhans** in the pancreas produce a hormone, but the rest of the organ produces **digestive juice** which contains enzymes **not** hormones.



Gland	Situated	Hormone produced	Target organ	Effect of hormone
Adrenal	above the kidneys	ADRENALINE (the 'fight, fright and flight' hormone)	liver	turns glycogen into glucose to boost blood sugar levels in emergencies
			heart	heart beats faster – more oxygen to brain and muscles
			voluntary muscles	tire less easily
Islets of Langerhans	in the pancreas	INSULIN	liver and muscles	promotes the uptake of glucose by cells promotes the conversion of glucose to glycogen for storage

Position of glands and their function



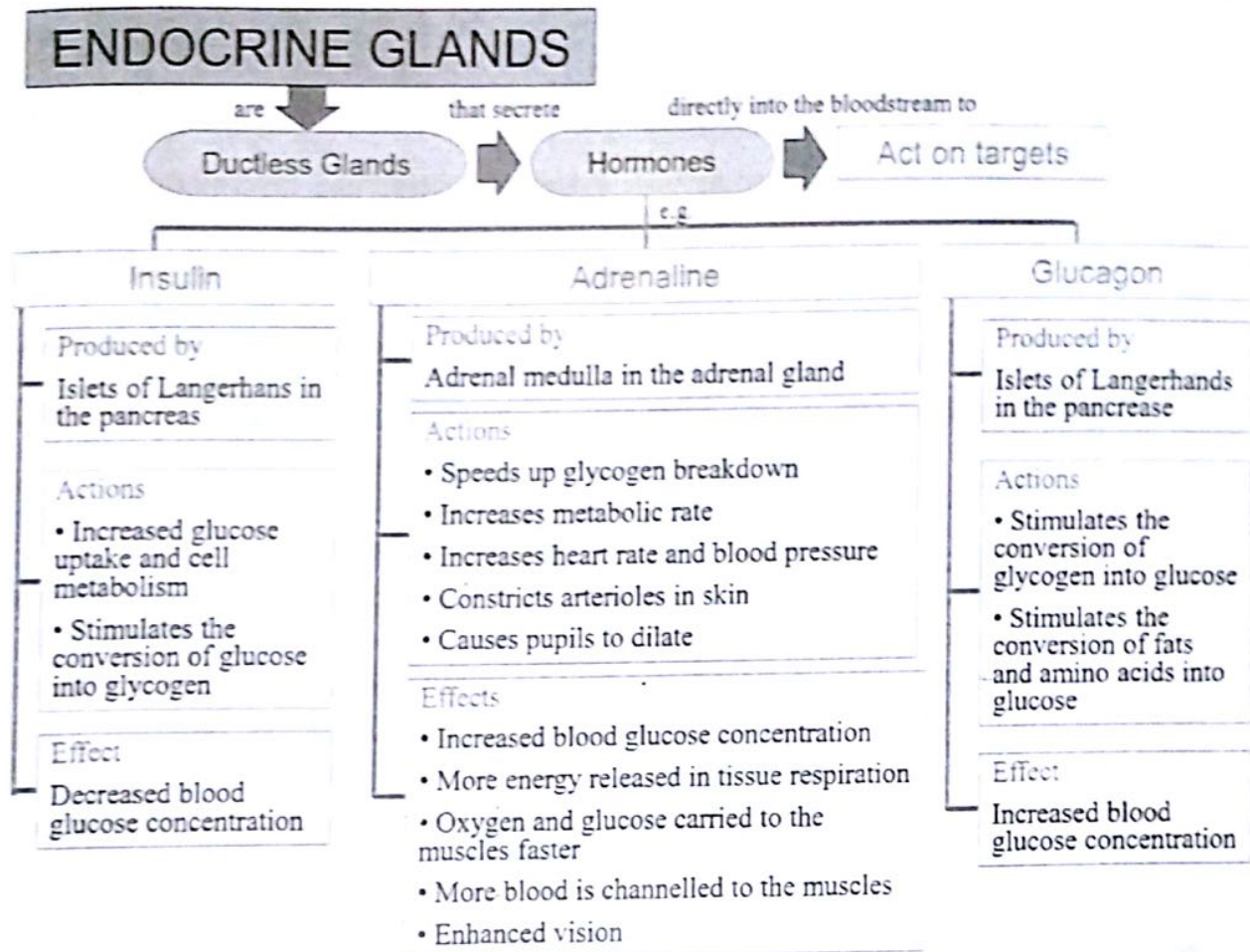
Diabetes

If a person's Islet of Langerhans cells do not produce enough insulin, the level of **glucose** in their blood will **rise**. **Glucose** will be present in their **urine**. The increased concentration of their blood plasma will draw **water** from their cells by osmosis, making them thirsty, tired, and causing them to urinate more frequently.

If insulin production is not seriously reduced, it may be possible to treat the condition by **restricting** the person's intake of carbohydrate. In **more extreme cases**, however, the **treatment** will include regular **injections** of insulin. The carbohydrate intake must then be regulated to match the amount of insulin injected.

For Books Order
0321-1100570

Concept Map of Hormones



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Syllabus Check List Coordination and Response

After reading chapter are you able to:

- ☐ state that the nervous system (brain, spinal cord and nerves) serves to coordinate and regulate bodily functions
- ☐ identify, on diagrams of the central nervous system, the cerebrum, cerebellum, pituitary gland and hypothalamus, medulla, spinal cord and nerves
- ☐ describe the principal functions of the above structures in terms of coordinating and regulating bodily functions
- ☐ describe the gross structure of the eye as seen in front view and in horizontal section
- ☐ state the principal functions of component parts of the eye in producing a focused image of near and distant objects on the retina
- ☐ describe the pupil reflex in response to bright and dim light
- ☐ outline the functions of sensory neurones, relay neurones and motor neurones
- ☐ discuss the function of the brain and spinal cord in producing a coordinated response as a result of a specific stimulus (reflex action)
- ☐ define a hormone as a chemical substance, produced by a gland, carried by the blood, which alters the activity of one or more specific target organs and is then destroyed by the liver
- ☐ state the role of the hormone adrenaline in boosting the blood glucose concentration and give examples of situations in which this may occur
- ☐ state the role of the hormone insulin in controlling blood glucose concentration
- ☐ describe the signs (increased blood glucose concentration and glucose in urine) and treatment (administration of insulin) of diabetes mellitus.

O-LEVEL BIOLOGY

Topic 12: Support, Movement and Locomotion

NOTES BY

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Syllabus 2017 – 2019

Content

12.1 Bones

12.2 Joints

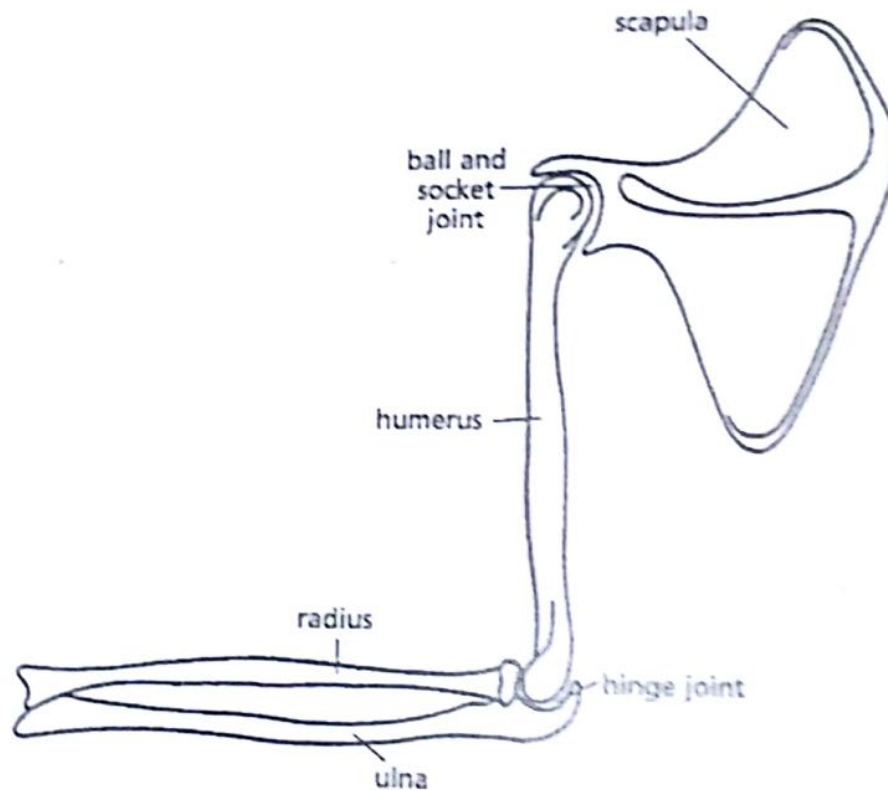
12.3 Antagonistic muscles

SUPPORT, MOVEMENT AND LOCOMOTION

The term **support** refers to the skeleton and its role in holding up the body structure and giving it shape. Whereas the term **movement** refers to the change in the position of one part of the body in relation to another part and term **locomotion** refers to the movement of the entire body from one place to another.

In most animals movement and locomotion could not occur without the **contraction** of **muscles**. Muscles provide the necessary **force**. The bones of the **skeleton**, to which the muscles are attached, operate as **levers**. They also support the body clear of the ground.

The arrangement of bones in a limb is illustrated by the human arm (a mammalian forelimb).



Some bones are strongly fused together to provide protection like in the skull. But most bones are able to move freely on one another in order to permit movement. The two main types of joints based on the movement are seen in the arm:

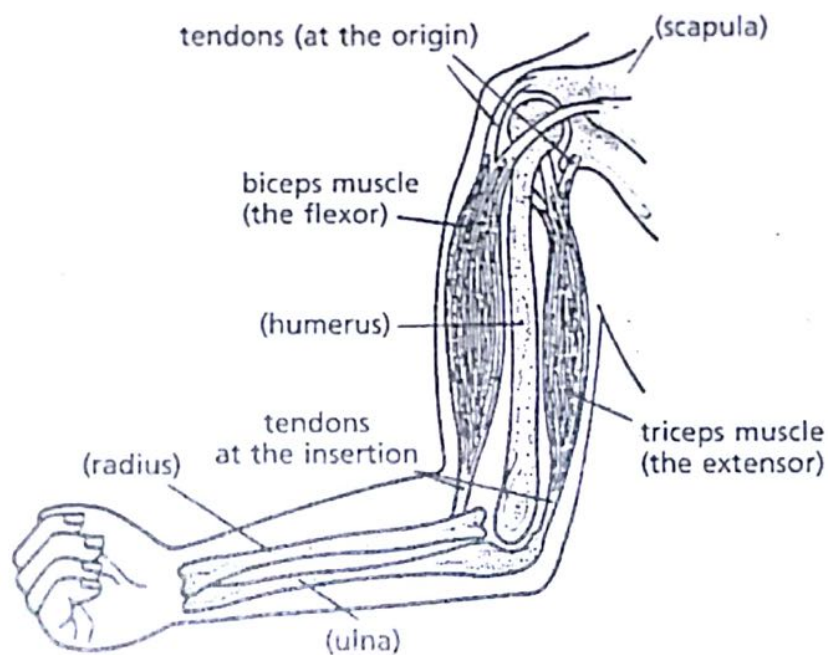
- (i) The **ball and socket joint** at the shoulder which allows free movement in **many planes**; though not quite 'all-around' movement.
- (ii) The **hinge joint** at the elbow which allows movement in **one plane only**.

How muscles move bones at a joint

Muscles work in the following way:

- (i) They can **pull** but never push.
- (ii) They **pull only** when they **contract**.
- (iii) When they contract, they **decrease** in length.
- (iv) When returning to their original length, they **relax not expand**.

- (v) They are attached to bones by **tendons** which do not stretch. They are arranged in **antagonistic pairs**, and apply their force either side of the bone they are required to move.
- (vi) One muscle of the pair (the **flexor**) **contracts** to bend the limb at the joint. As it does so, the other muscle in the pair (the **extensor**) **relaxes**.
- (vii) The extensor contracts to straighten the limb at the joint, and as it does so, the flexor relaxes. The arrangement of the antagonistic muscles at the hinge joint of the elbow are shown below.



Syllabus Check List Support, Movement and Locomotion

After reading chapter are you able to:

- ☐ identify and describe, from diagrams, photographs and real specimens, the main bones of the forelimb (humerus, radius, ulna and scapula) of a mammal
- ☐ describe the type of movement permitted by the ball and socket joint and the hinge joint of the forelimb
- ☐ describe the action of the antagonistic muscles at the hinge joint.

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O-LEVEL

BIOLOGY

Content

13.1 Antibiotics

13.2 Effects of heroin

13.3 Effects of alcohol

13.4 Effects of tobacco smoke

Topic 13: The Use and Abuse of Drugs

NOTES BY

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THE USE AND ABUSE OF DRUGS

Hormones are chemical manufactured by and within a living organism, which have a specific effect on that organism's metabolism. Chemicals not made by the organism may be introduced into the body of the organism for a specific effect. These chemicals are called **drugs**.

A **drug** is an extremely-administered substance which modifies or affects chemical reactions in the body.

Drugs may be used for **beneficial** effects:

- (i) For **pain relief** (aspirin, paracetamol, and morphine)
- (ii) For **treatment of disease**. Diseases caused by **bacteria**, such as **syphilis**, are treated with drugs called **antibiotics**. A well-known antibiotic is **penicillin**.
- (iii) Drugs are also used for their **mood influencing** effect. This can be useful for treating patients with emotional disorders such as **depression**.

Drug abuse

If a drug is taken simply for enjoyment, often in large amounts, it can lead to **addiction**.

Heroin

Heroin is a drug which is abused for enjoyment and ultimately lead to addiction. Heroin effects the users in the following way:

- It is a **powerful depressant** that has a sedative effect. It removes feelings of anxiety, and creates a sense of extreme well-being. Heroin is a drug to which the body shows tolerance. This means that progressively **increased** dosages are needed to maintain (or produce) the feelings of well-being.
- The person using the drug may end up in a state of **dependence**, where they crave the drug and cannot face life without it. If they cannot get further supplies, they suffer serve withdrawal symptoms, like diarrhoea, vomiting, muscular pain, shaking and hallucination.
- Addiction can lead the user into a life of **crime** to get money and/or regular supplies of the drug.
- Heroin is a drug normally taken by injection into a vein. If several addicts use the same unsterilized needles, they are at high risk of contracting blood-borne diseases such as **hepatitis** and **AIDS**.

Alcohol

Alcohol is widely used and readily available in many societies, where it is generally regarded as a more 'socially acceptable' drug. However, it has these effects:

- (i) It is a **depressant**, creating a feeling of well-being.
- (ii) It **slows reaction times** (increasing the risk of accident).
- (iii) When consumed in **excessive** quantities it leads to **loss of self-control**. Many people under the influence of alcohol behave in a way they would be ashamed of when sober.
- (iv) It also leads to **liver damage** which can eventually prove fatal.

Like heroin, alcohol is a drug of addiction. Withdrawal symptoms are not as severe as those for heroin, but a person may go to great lengths to satisfy their cravings. Often their families suffer as a consequence, not only from financial hardship, but also from physical violence, which often accompanies alcoholism.

Nicotine

Nicotine is the drug of addiction present in cigarette smoke. A person relatively suffers mild withdrawal symptoms if their craving for nicotine is not satisfied. This drug has the following effects:

- (i) It is a **poison** which **increases** heart rate and **blood pressure**.
- (ii) It may cause **blood clotting**, increasing the risk of **thrombosis** (blockage in a blood vessel). Thrombosis in the coronary artery will result in a heart 'attack'.

Other harmful components of cigarette smoke includes:

- (i) **Tar** forms a layer over the walls of the alveoli, restricting gaseous exchange. Tar is also a **carcinogen** and prolonged exposure to it may lead to **lung cancer**.
- (ii) **Carbon monoxide** is taken up, permanently, by **haemoglobin** in preference to oxygen (forming carboxyhaemoglobin). It greatly **reduces** the ability of the **blood** to carry **oxygen**.
- (iii) **Irritant chemicals** in smoke cause the cells lining the bronchi and bronchioles to increase their production of **mucus**. These chemicals also **destroy the cilia** lining the trachea. Cilia sweep away the dirt in a 'moving carpet' of mucus and carry it to the throat for swallowing. The build-up of mucus is relieved only by continual coughing ('**smoker's cough**'). Persistent coughing may damage the walls of the alveoli, allowing them to become over-stretched. This may lead to **emphysema**. Irritant chemicals also cause inflammation of the bronchi (**bronchitis**) and may increase the risk of secondary bacterial infection of the bronchial walls.
- (iv) A pregnant woman who smokes also **risks the health of her baby**. **Less oxygen** reaches the baby as a result of the effects of carbon monoxide, and **nicotine** can pass from mother's to baby's blood. Babies born to mothers who smoke during pregnancy have been shown to be **underweight**, perhaps less intelligent, and there is a greater risk of **miscarriage**.
- (v) **Passive smoking**. Evidence now exists that breathing the smoke from other people's cigarettes can be harmful. Cigarette smoke is certainly an **irritant** to the eyes and leaves a lingering smell in clothes. Smoking is therefore increasingly becoming a **socially unacceptable** habit.

Syllabus Check List The Use and Abuse of Drugs

After reading chapter are you able to:

- ☐ define a drug as any externally administered substance that modifies or affects chemical reactions in the body
- ☐ describe the medicinal use of antibiotics for the treatment of bacterial infection
- ☐ describe the effects of the abuse of heroin: a powerful depressant, problems of addiction, severe withdrawal symptoms and associated problems such as crime and infection, e.g. AIDS
- ☐ describe the effects of excessive consumption of alcohol: reduced self-control, depressant, effect on reaction times, damage to liver and social implications
- ☐ describe the effects of tobacco smoke and its major toxic components (nicotine, tar and carbon monoxide) on health: strong association with bronchitis, emphysema, lung cancer and heart disease, and the association between smoking during pregnancy and reduced birth weight of the baby
- ☐ recognise the fact that many people regard smoking as no longer socially acceptable.

O-LEVEL
BIOLOGY

Topic 14:
Microorganisms
and
Biotechnology

NOTES BY

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Syllabus 2017 – 2019

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- 14.1 Microorganisms
- 14.2 Food biotechnology
- 14.3 Industrial biotechnology

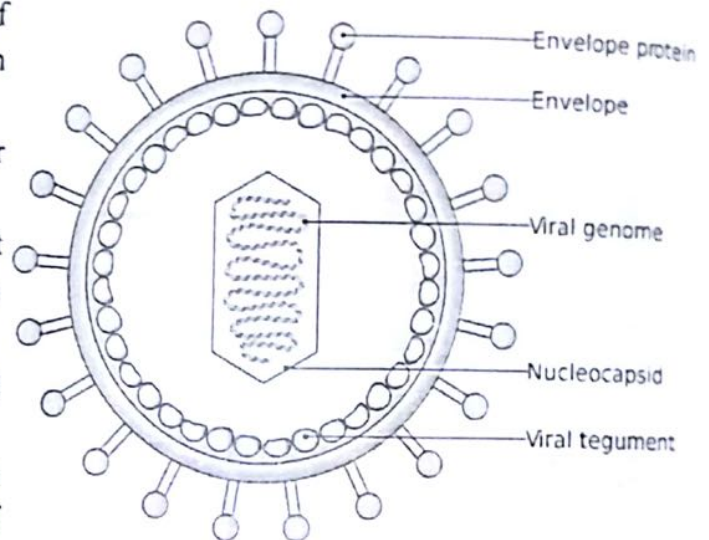
MICROORGANISMS AND BIOTECHNOLOGY

Microorganisms are organisms which are studied only with the aid of a microscope. Often, they are made up of one cell only and for that reason they are called **unicellular**. Virus, bacteria and fungi are few examples of microorganisms.

Viruses

Viruses are such simple organisms that biologists do not regard them as truly living. They have the following main characteristics:

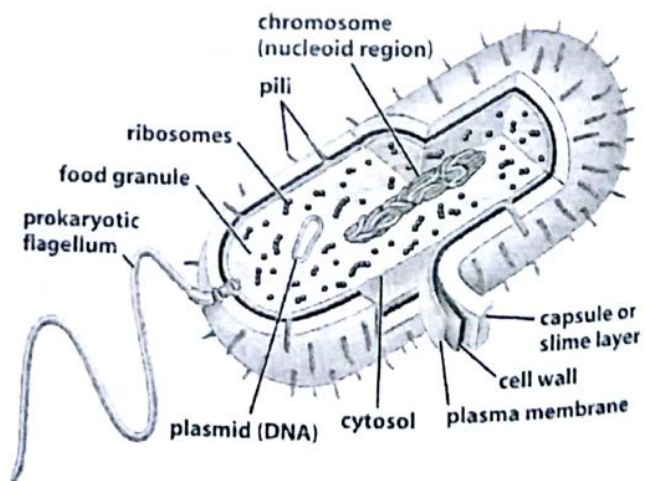
- They are less than 300 nm in size – around 50 times smaller than a bacterium (1 nm, or nanometer, is one thousand millionth of a metre). They can be seen only with an **electron microscope**.
- They contain **nucleic acid** (DNA or RNA).
- The nucleic acid is surrounded by a coat (two, in the case of HIV) of **protein** (known as the **capsid**).
- They can **reproduce only inside living** ('host') cells.
- They are **parasites**, and **cause disease** (they are **pathogenic**). Examples of disease caused by viruses are influenza, measles and AIDS.
- Viruses are **not affected by antibiotics**.



Bacteria

Bacteria are the simplest of the living organisms. They have the following characteristics:

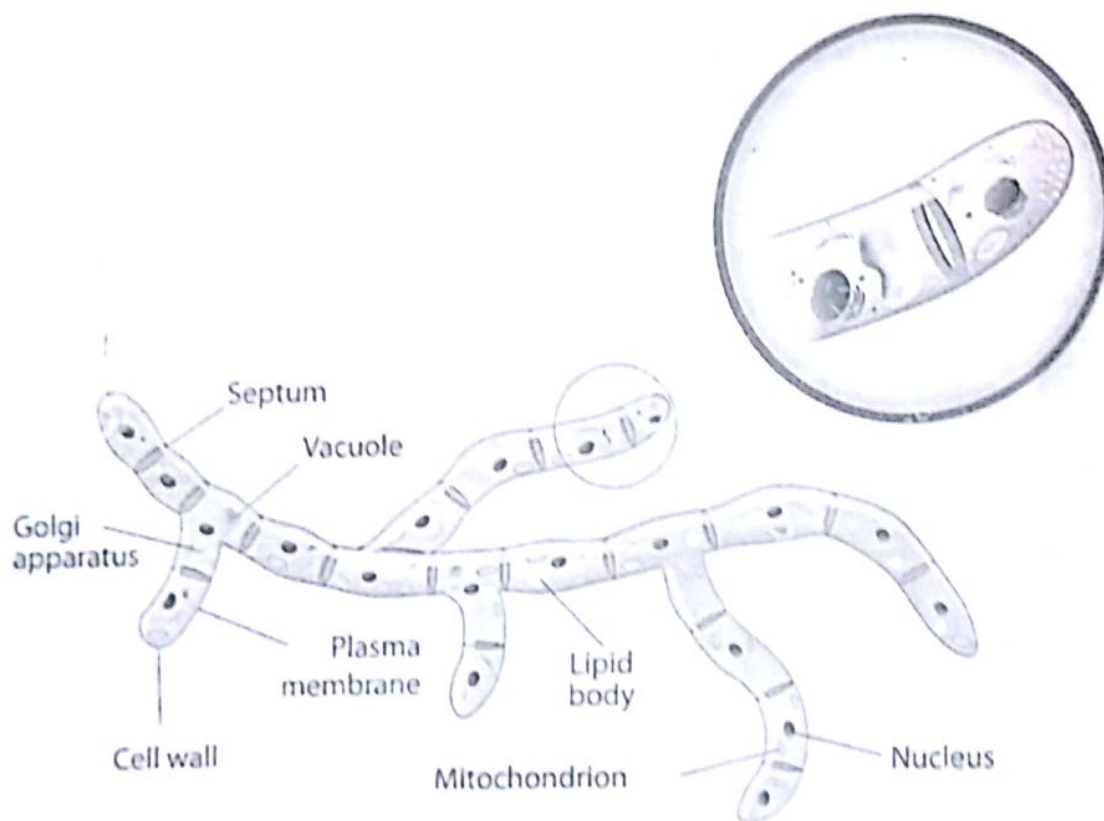
- They have a size in the range of 0.5–5 μm ($1 \mu\text{m} = \frac{1}{1000} \text{ mm}$).
- They are **unicellular**.
- They have **no true nucleus** (their DNA lies 'loose' in the cytoplasm).
- They have a **cell wall**.
- They may be (pathogenic) parasites or they may be saprotrophs – feeding on dead organic matter causing it to decay. Some may be involved in **nitrogen fixation**.
- They are killed by **antibiotics**.



Fungi

Fungi are usually much larger organisms, visible to the naked eye. They have the following characteristics:

- They have **no chlorophyll**, and thus have **heterotrophic** nutrition: digesting large molecules with **enzymes** and absorbing the soluble products. They are **parasites** or **saprotrophs**.
- They have a 'cell' wall made of **chitin**.
- They are usually made of a large number of tubular threads (**hyphae**) intertwined to form a **mycelium**.
- Hyphae are not divided into individual cells. The lining of **cytoplasm** has many **nuclei** and the central space in the hyphae is a **vacuole** full of (vacuolar) sap.
- If they store carbohydrate, they store **glycogen**.
- They reproduce by producing **spores**.



The role of microorganisms in decomposition

Many microorganisms such as bacteria and fungi feed as **saprotrophs**, using **external digestion**. They release **enzymes** onto their dead organic substrate ('food'). These enzymes are:

- (i) **Protease** which digests proteins to amino acids. Amino acids are then further broken down to ammonium ions.
- (ii) **Amylase** which digests starch to simple sugars.
- (iii) **Lipase** which digests fats to fatty acids and glycerol.

Some of the end-products are absorbed by the microorganisms for use in their own metabolism. For example, amino acids for building up proteins during growth; sugars for energy release during respiration – with CO_2 and H_2O as waste products; fats for energy storage. Gradually, the dead matter is broken down, releasing its mineral ions which are returned to the soil for recycling as they are taken up for use by plants.

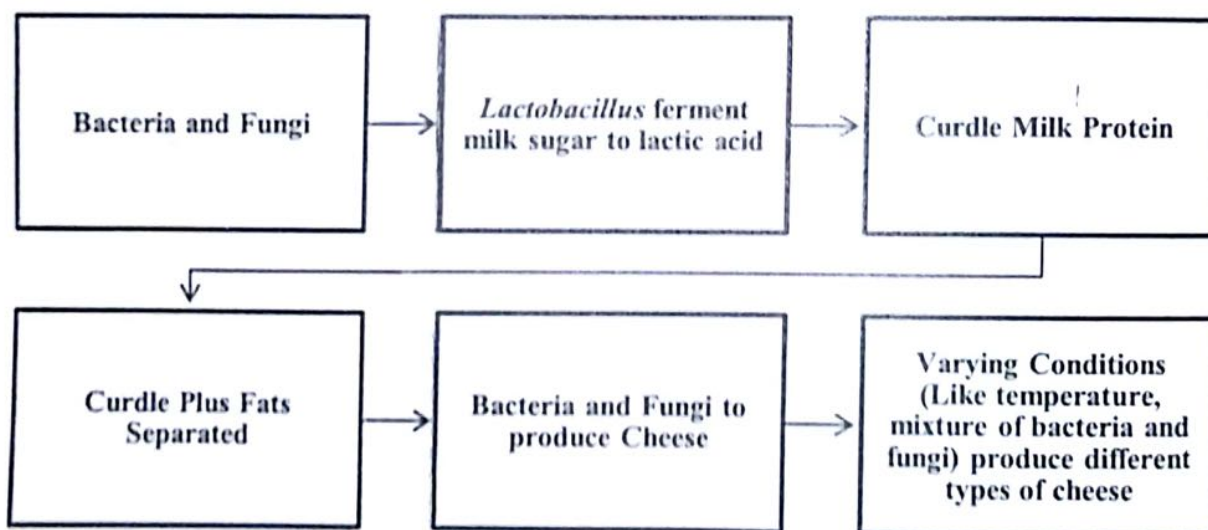
The roles of bacteria and fungi in food production

Bacteria and yoghurt

Milk is heated at 90°C , then cooled to between 40°C and 45°C . The correct species of bacterium (e.g. *Lactobacillus*) is added and the milk is kept at this temperature for 24–36 hours. Over this time the bacteria convert milk sugar (lactose) into lactic acid by anaerobic respiration. The acid curdles the milk to produce the characteristics texture and sharp flavor of yoghurt.

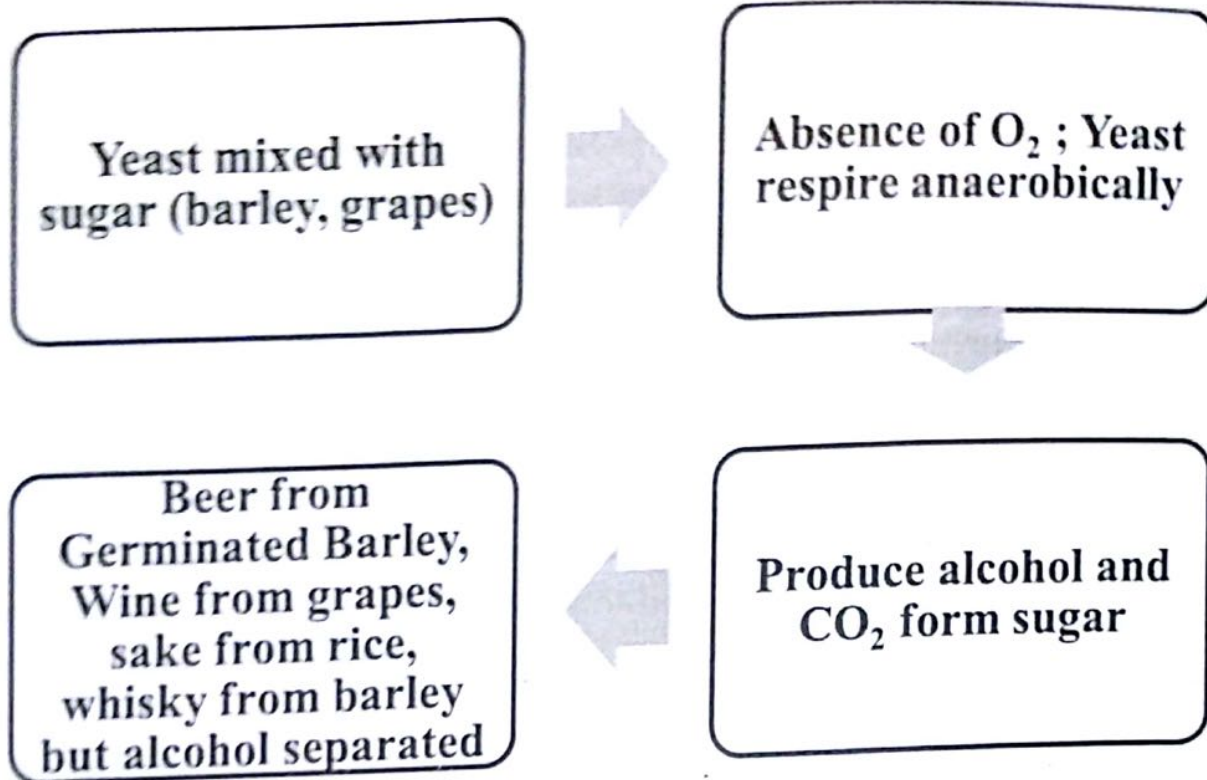
Bacteria and cheese

Milk is warmed to 40°C , inoculated with bacteria (e.g. *Streptococcus*) and mixed with rennin, an enzyme found in the stomachs of young mammals. Lactic acid produced by the bacteria creates the correct pH for the rennin to work. The milk clots. The solid part (the curd) is separated from the liquid (the whey). The curds are pressed and moulded and left to mature, or ripen. Sometimes, further bacteria are added to provide flavor, e.g. from copper wire which are drawn through the dried curds.



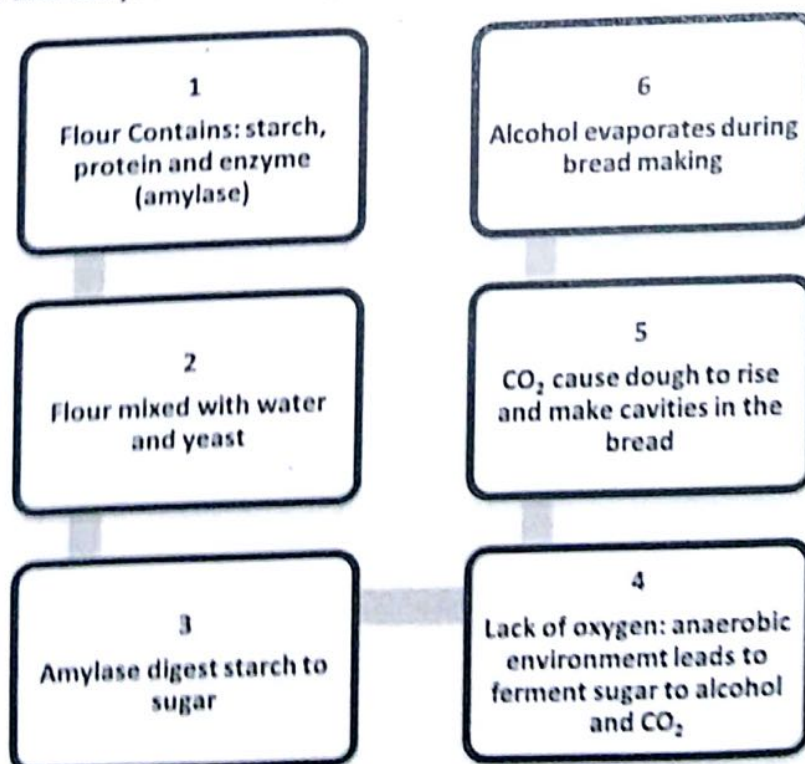
Yeast and alcohol

Yeast is a fungus that is added to a sugar solution to make alcohol. For example, to make wine, yeast is added to fruit sugar from grapes; to make beer, it is added to maltose from barley. The yeast is allowed to ferment the sugar at a controlled temperature in a vessel called a fermenter. The optimum temperature for the growth of yeast is around 20°C . The yeast converts the sugar to alcohol by anaerobic respiration, with carbon dioxide evolved as a waste product. As the concentration of alcohol rises, it eventually kills the yeast, which must then be filtered from the liquor to produce a yeast-free alcoholic drink. Drinks with a higher alcoholic content, such as spirits, are produced by distillation of the original alcoholic drink. For example, brandy is distilled wine.



Yeast and bread

A process similar to the one described above occurs in bread-making. Flour and water are used to make a dough, then yeast and a little sugar are added. Although alcohol is produced by the anaerobic respiration of the yeast, it is the **carbon dioxide** which is important. The mixture is left in a **warm** place for around half an hour (depending on temperature) for the dough to 'prove'. The carbon dioxide gas causes the dough to rise, giving it a light mixture. The dough is then **baked at high temperature** in an oven. The high temperature cooks the bread and also evaporates the alcohol produced during fermentation.



Industrial biotechnology

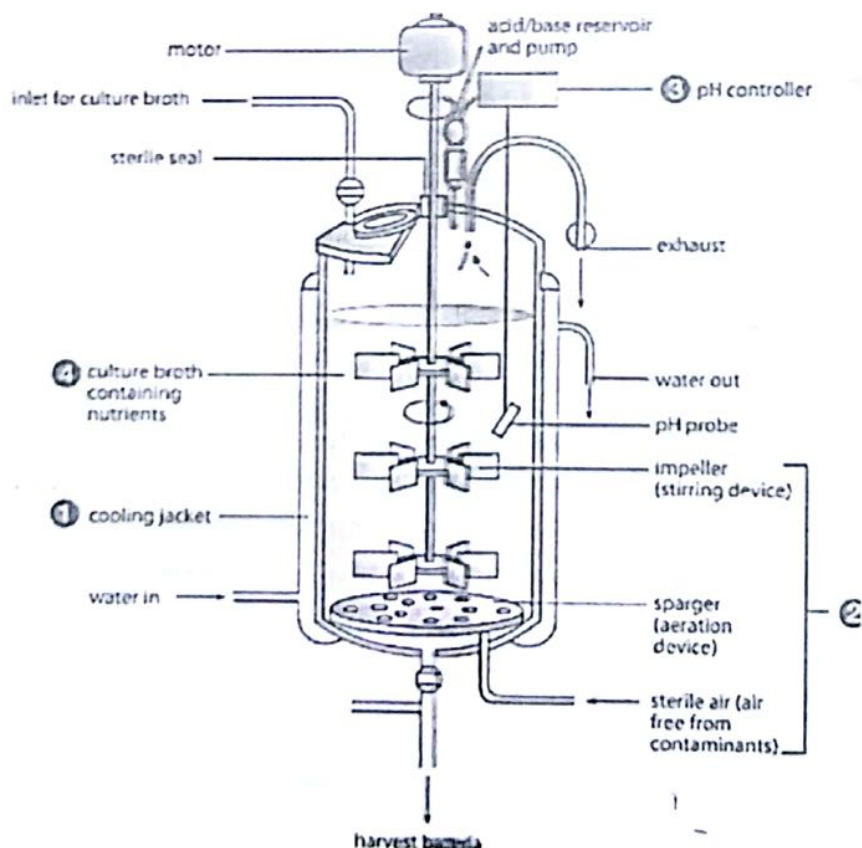
Industrial Biotechnology is the use of microorganisms in industrial processes, for example, in the manufacture of **antibiotics** and **single-cell protein (SCP)**. Large quantities of end-product (antibiotic or SCP) are required, so the microorganisms involved are grown in very large containers called **fermenters**. A **maximum rate of growth** of the microorganism within the fermenter can be achieved by careful control of

- (i) the **temperature**
- (ii) the type and concentration of **substrate** (i.e. the substance on which the microorganism works)
- (iii) the **oxygen availability**

Thus, fermenters are unaffected by climate, **soil type** or, in temperate regions, time of year. Fermenters must be kept **sterile** to prevent the **growth** of unwanted species of microorganism which might contaminate the end-product.

Characteristics of a fermenter

1. **Cooling system:** Heat from bacteria growth is removed by pumping water in through the base of a cooling jacket.
2. **Aeration system:** Adequate aeration promotes growth and two devices can help. Sterile air is forced through the tiny holes of a **sparger** and the numerous bubbles dissolve in the nutrient broth. An impeller spreads the oxygen and nutrients out evenly and also ensures that bacteria does not clump together.
3. **pH controller:** A pH probe measures the **pH** of the broth and makes the adjustments accordingly.
4. **Nutrients:** The nutrient broth should contain a carbon and energy source e.g. glucose, a nitrogen source e.g. amino acids or nitrates and essential mineral salts.



Antibiotic production

Pathogenic (disease-causing) bacteria are killed by certain chemical (antibiotics) released by other microorganisms, especially fungi. For example, the mould fungus *Penicillium*, which grows naturally on stale bread, may be cultured on a sterile medium in a laboratory. The fungus is then introduced into a **fermenter** for commercial production. The fermenter (up to 100,000 litres in volume) contains a suitable sterile medium on which the fungus can grow.

After an appropriate period of time, when the rate of fungal growth becomes limited by the amount of food available, the contents of the fermenter are crushed and filtered. The liquid part contains the antibiotic (in this case, **penicillin**), which is separated and purified. The rest of the material may be dried and used as cattle feed.

Single-cell protein production

Bacteria and fungi contain cytoplasm, and a major constituent of cytoplasm is **protein**. Therefore, large-scale production of bacteria and fungi involves the large-scale production of protein. The microorganisms can be grown in a fermenter, harvested and used as a protein source, known as SCP. If the microorganisms involved are fungi, then, more accurately, the protein is known as **mycoprotein**.

Many microorganisms will grow successfully on industrial waste materials as a substrate. Examples are: waste from oil refining, waste from sugar refining (molasses), whey from cheese manufacture, and straw.

Syllabus Check List Microorganisms and Biotechnology

After reading chapter are you able to:

- ☐ list the main characteristics of the following groups: viruses, bacteria and fungi
- ☐ outline the role of microorganisms in decomposition
- ☐ explain the role of yeast in the production of bread and alcohol
- ☐ outline the role of bacteria in yoghurt and cheese production
- ☐ describe the use of fermenters for large-scale production of antibiotics and single cell protein
- ☐ describe the role of the fungus *Penicillium* in the production of penicillin.

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Content

- 15.1 Energy flow
- 15.2 Food chains and food webs
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- 15.7 Pollution
- 15.8 Conservation

O-LEVEL

BIOLOGY

Topic ¹⁵6:

Relationship of Organisms with one another and with Environment

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RELATIONSHIP OF ORGANISMS WITH ONE ANOTHER AND WITH ENVIRONMENT

Energy flow

The source of energy for all life on the planet is the sun. Living organisms use that energy for their activities. So long as the sun continues to shine, life can continue.

The heat energy from the sun is used by organisms such as 'cold-blooded' animals to keep their bodies warm. The sun also supplies light energy, which is locked away by plants during photosynthesis to form chemical energy in food molecules. A plant's (producer) chemical energy is passed on to an animal (consumer) when the animal eats the plant and process is called feeding. If that animal is eaten by another animal, the energy is passed on again as result of feeding.

In this way, the sun's energy enters then flows through biological ecosystems, and is gradually lost (as result of respiration) by different organisms to the environment as it passes from one organism to the next. Some of energy is also lost in form of excretory products and dead bodies of the organisms which are later on decomposed by decomposers and heat is lost to the environment. Once energy is lost to the environment it is never recycled.

Food chains and food webs

A food chain is a sequence of organisms, starting with a photosynthesizing organism (usually a green plant), through which energy is passed as one organism is eaten by the next in the sequence. An example of food chain is shown below.



A food chain is a series of organisms through which energy is transferred in the form of food.



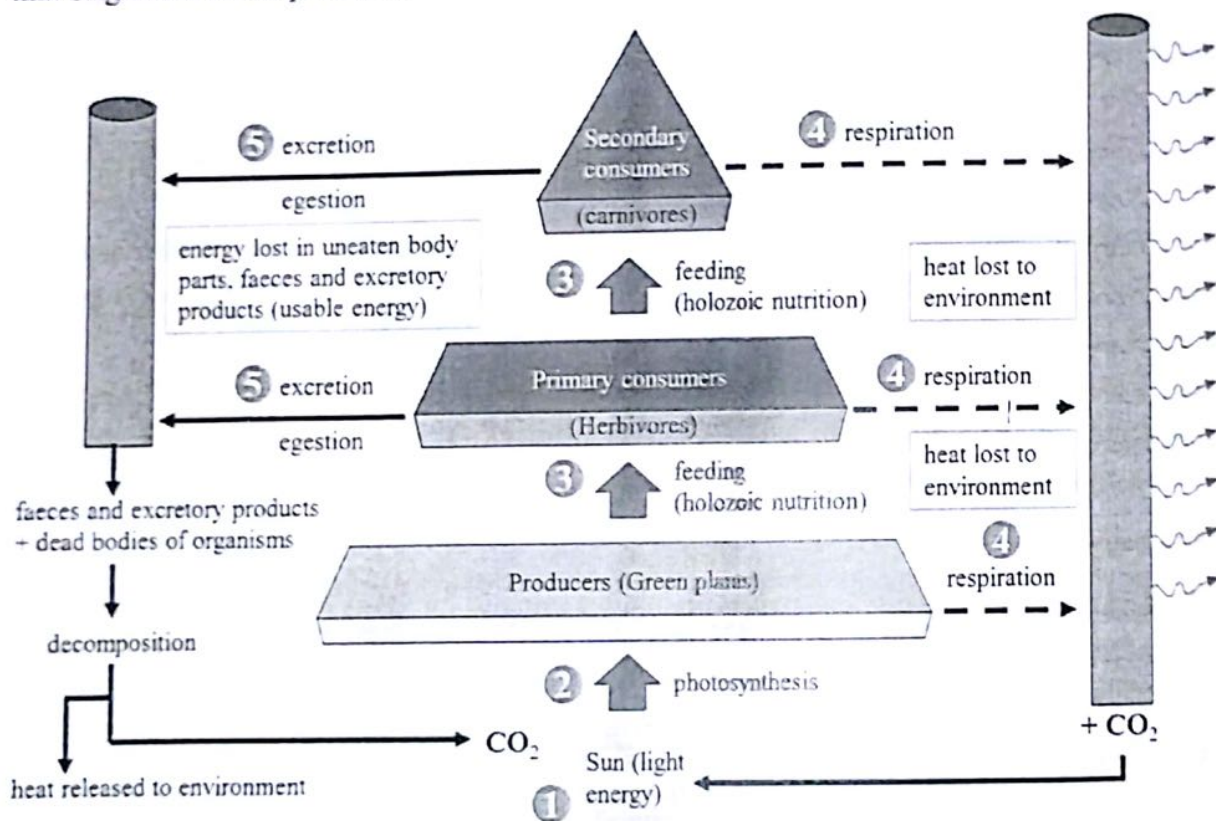
Many of the food chains are interlinked, so a food web is made up of interlinked food chains involving organisms within the same ecosystem.

Energy loss along a food chain

Some of the energy locked away by producers (plants) is **released** by the producer itself through the process of respiration. Some of the energy is **used** by the producer, for example, in the processes of **cell division, growth and reproduction**. A lot of energy is still present when a plant dies, and is then available to decomposers. Only about 10% of a plant's available energy is passed on to the herbivores which eat it.

Herbivores then **release the energy** by respiration, and use it for growth, movement and, as heat, to maintain body temperature.

Much of the energy is still present in the faeces of herbivores, and some in the nitrogenous waste. This is available to decomposers. Not all herbivores are eaten, so the amount of energy available to be passed on to carnivores is small, at around 20%. This is only 2% of the amount that originated in the producer.



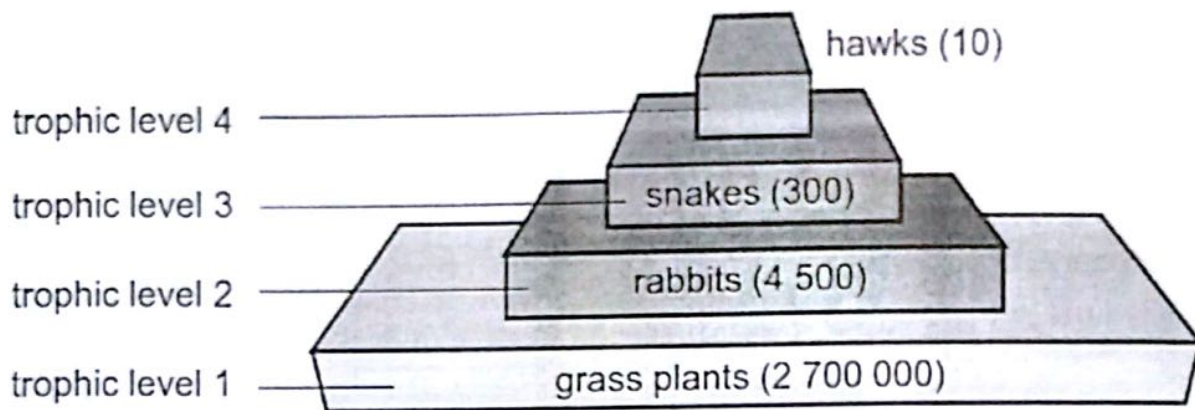
Advantages of a short food chain

The longer the food chain, the less energy available to the carnivore at the end of the chain. **Short food chains are therefore much more energy-efficient** than long ones. In order to supply enough energy in food to maintain an ever-increasing world population, it must be realised that far less energy is lost when humans eat green plants than when crop plants are fed to animals which are then eaten by humans.

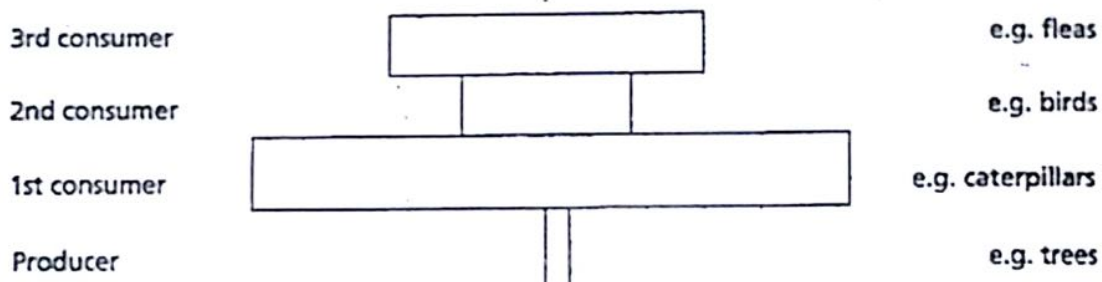
Pyramids of numbers, biomass and energy

Producers (plants) need to produce enough food – and therefore enough energy – for their own metabolic processes. They must also provide enough food for the herbivore that eat them, and leave enough surviving individuals to reproduce the next generation. Therefore, we would expect there to be a **larger number of producers than primary consumers (herbivores)**. For

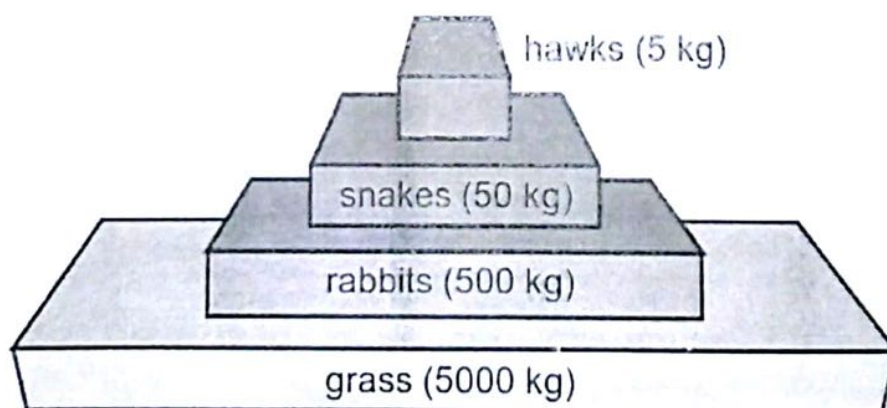
the same reasons, we would expect there to be more primary consumers than secondary consumers, and so on. These decreasing numbers along a food web can be represented in the form of a **pyramid of number**.



However, this representation of feeding relationships can be misleading: one large plant may sustain a large number of very small herbivore; and one carnivore may sustain a large number of smaller carnivores. If this is the case, we see a 'top heavy' pyramid, as shown below.

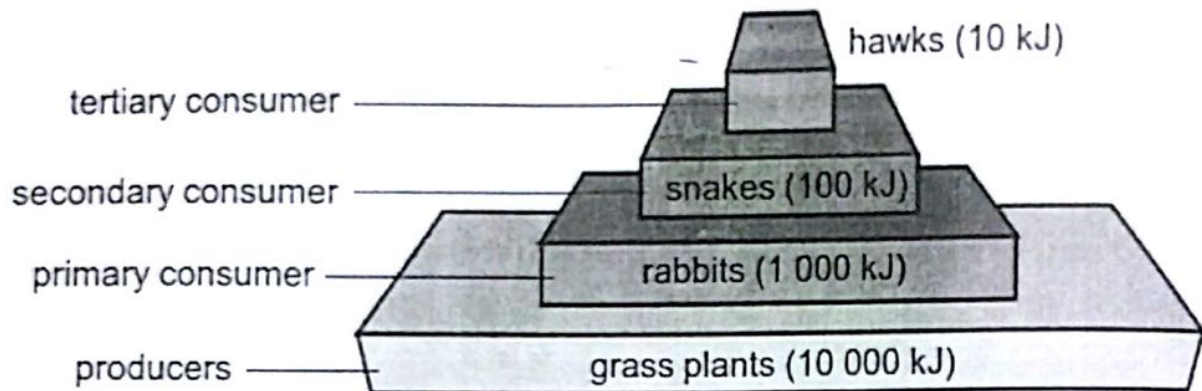


A **pyramid of biomass** is a pyramid constructed using the **dry mass** of organisms at each trophic level in a food chain (or food web). It produces pyramids of a more standard shape and can be constructed by collecting data from population estimate in any particular habitat. Biomass is the total dry mass of a population, i.e. the theoretical mass of chemicals **other than water** in the organisms under consideration (water can vary considerably).



A **pyramid of energy** is the most reliable of all the representations of the interactions between organisms in a food web. It shows how much **energy** is passed from one trophic level to the next, within organisms in a food web, **over a period of time**. It thus allows for the growth of producers over that period, and thus can show **productivity** (how much organic material is made) and how much energy is passed on, during that period, to the herbivores. Its **shape** is

that of a **standard pyramid** (like the pyramid of biomass), but the **information** necessary to construct it is **difficult to obtain**, since it requires knowing how much of all the different foodstuffs are manufactured by the producer, how much energy they contain, and how much of each foodstuff is passed on to each member of the food web.



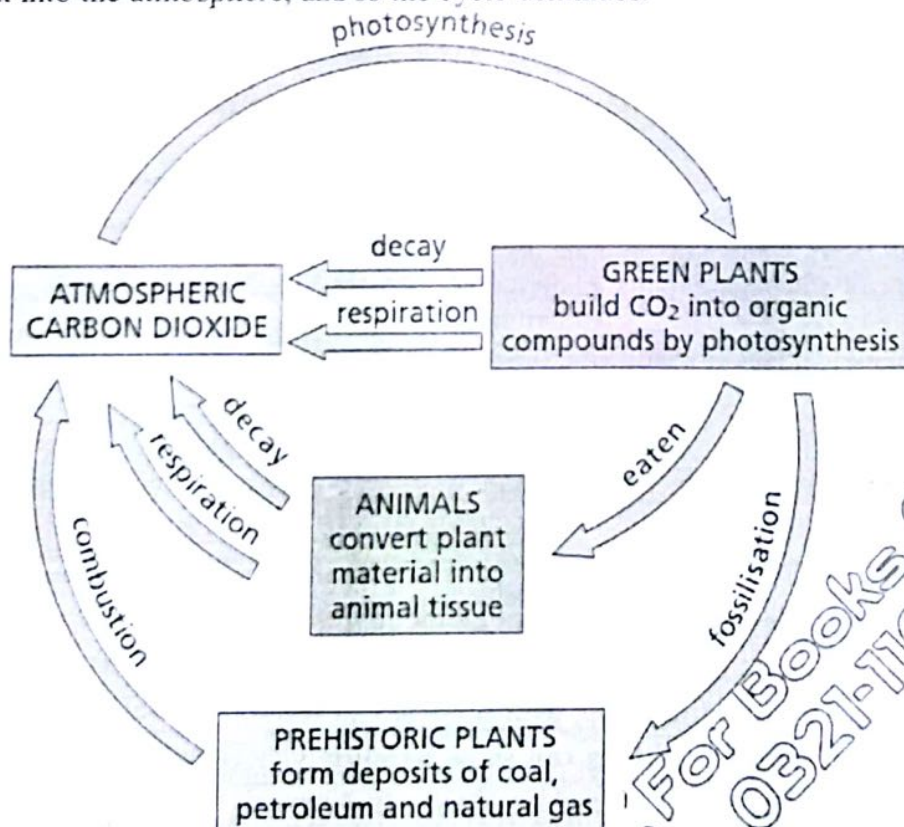
The carbon cycle

When **decomposition** occurs, carbohydrates in the dead organic matter are used as the substrate for respiration by decomposers (bacteria and fungi). **Carbon dioxide is released** into the atmosphere, as it is in all cases of aerobic **respiration**.

Combustion, the burning of fuels, also **releases carbon dioxide** into the atmosphere. Many of these fuels are **fossil fuels** such as coal, gas and oil.

Photosynthesis absorbs that carbon dioxide and converts it into carbohydrates (which may then be used to make fats or proteins) in a plant.

Animal nutrition involves the transfer of these carbon-containing molecules to animals. Animals and plants **respire**, and eventually die and are decomposed, releasing the carbon dioxide back into the atmosphere, and so the cycle continues.



The nitrogen cycle

Decomposition includes the conversion by bacteria of **proteins** to **amino acids**, and the conversion of amino acids and **urea** to **ammonium ions**. This process usually takes place in the **soil**.

Ammonium ions contain **nitrogen** atoms, but before plants can absorb nitrogen from the soil, it must be in the form of **nitrate** ion.

Nitrifying bacteria convert ammonium ions first into **nitrites** then into **nitrates**.

Plants absorb the nitrates and use them together with the carbohydrates made by photosynthesis, to make amino acids and then **proteins**.

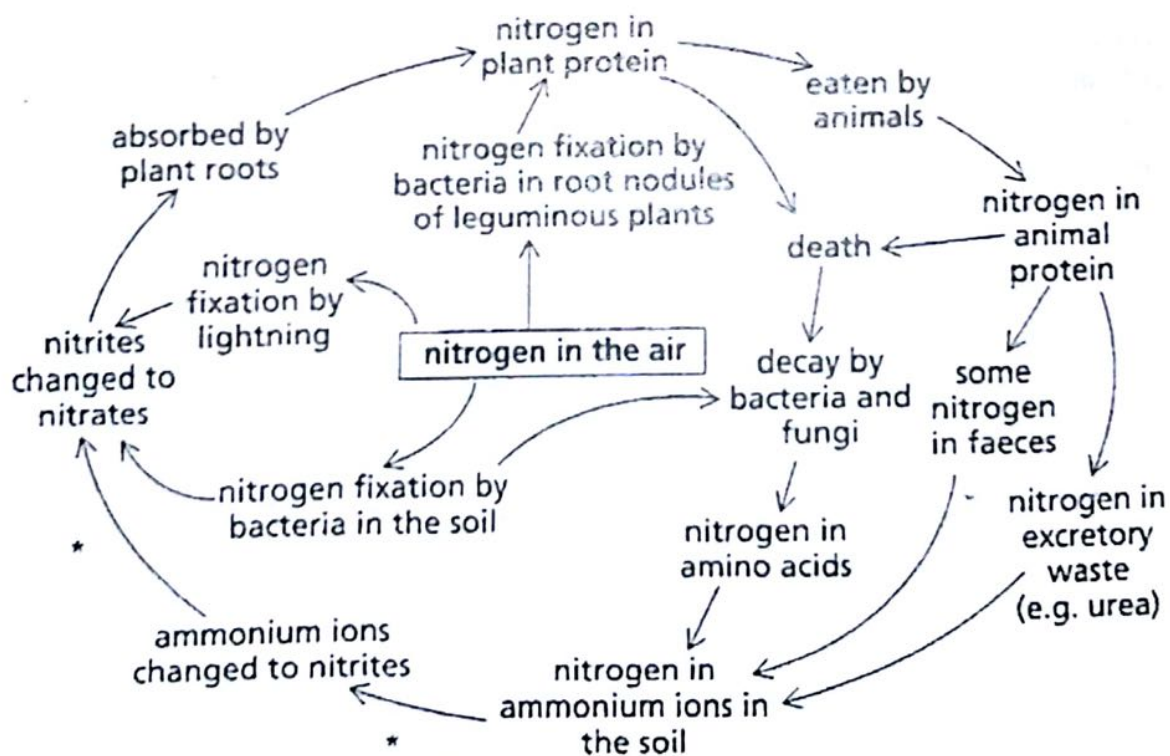
Animals eat the protein in plants and excrete, e.g. urea. Both plants and animal die, and decomposition releases ammonium ions again.

Atmospheric nitrogen (79% of the air) cannot be used either by plants or by animals in its gaseous form, but it is used by some bacteria (the **nitrogen fixing bacteria**). These bacteria are found in two forms:

- (i) Those which live in swellings called **nodules** on the roots of peas, beans and other **leguminous** plants.
- (ii) Those which live freely in the soil.

Nitrogen fixation by these bacteria changes the atmospheric nitrogen, via ammonia, into **proteins**. The nitrogen becomes available to other organisms when these proteins later decompose.

Nitrogen fixation also occurs when **lightning** passes through the nitrogen in the air, converting it to **nitric acid** which forms nitrates in the soil.



* The changes are brought about by nitrifying bacteria

Leaves fall to the ground where they decompose, forming humus in the soil. Humus provides a steady supply of **ions**. It acts as a sponge, soaking up and holding water in the soil, and helps to bind the soil together, preventing soil erosion.

Trees form a **canopy** which keeps the powerful sun's rays off more delicate organisms. The canopy also protects the soil from the force of tropical rainfall, and protects the soil, smaller plants and animals from the full force of high winds. Tree **roots** also help to bind the soil. Removal of the trees therefore **leads** to soil **erosion** caused by wind and water, and soil carried into rivers may lead to **flooding** further downstream as it is deposited on the bed of the river as silt.

2. The effect on climate

Trees supply enormous quantities of water vapour to the atmosphere through **transpiration**. Transpiration leads to the formation of clouds. Clouds are carried by the prevailing winds and eventually produce rain, usually in an area some distance away from where the vapour was released. Deforestation can therefore lead to distant regions receiving **reduced rainfall**. In the most extreme cases, relatively fertile areas can become **deserts**.

On a global scale, deforestation can reduce the amount of carbon dioxide taken in for photosynthesis. The **levels of carbon dioxide in the atmosphere rise**, acting as a 'thermal blanket' over the planet, preventing the natural escape of heat from our atmosphere. This is known as the **greenhouse effect**. It is believed to lead to **global warming**, which may affect the distribution of plants and animals (and eventually melt the ice caps).

3. The effect on local human populations

Deforestation is usually motivated by financial gain. Those who benefit may live outside the country where the deforestation is occurring. Many local residents **lose their homes** and see their **culture destroyed** along with the trees. Many people find it **difficult to adapt** to lifestyles which are geared to commercial success. The people living in the Amazon rainforest of South America are one example. The forest, their home, is one of the largest areas of deforestation in the world.

Pollution

Apart from the effects of deforestation, humans are also responsible for polluting the environment in a number of ways.

The pollution of water by sewage

Large human settlements create a considerable amount of sewage. Tipping sewage directly into streams and rivers can have these harmful effects:

- (i) Sewage contains pathogenic organisms. If the water is used for human consumption, then diseases, such as cholera, spread.
- (ii) Very high levels of sewage contain very large numbers of **bacteria** which use up the oxygen in the water for their own respiration. This does not leave enough oxygen for any other water life, so many organisms die.
- (iii) Smaller quantities of sewage release ions as it decomposes. The ions encourage rapid growth of water plants (**eutrophication**), which eventually die and decompose. The

bacteria of decomposition again use up so much oxygen in the water that no other life can exist.

The pollution of water by inorganic waste

- (i) **Household detergents**, discharged into rivers along with sewage, often contain **phosphates**. These encourage the growth of small water organisms (algae), leading to possible eutrophication.
- (ii) **Industrial wastes** such as those which contain **mercury** (e.g. from paper mills) and **copper** ('heavy metals') are highly toxic to all organisms. It is expensive to remove these wastes in a completely safe way, so they, too, are often discharged into rivers.

Polluted rivers discharge into **seas**. Polluted seas lead to contamination of producers in the sea's food chains. One small fish consumes many smaller contaminated food organisms. One large fish eats many smaller fish. In this way, the amount of poison gradually increases in the organisms along the food chain. If a human eats contaminated fish, they may consume harmful levels of poison.

Air pollution by sulphur dioxide

Sulphur dioxide is a gas which is released whenever fossil fuels are burnt. In industrial areas, the amounts of sulphur dioxide released into the air can be high. It is a gas linked with bronchitis and heart disease in humans.

In the air, sulphur dioxide dissolves in rain and falls to earth as a dilute solution of **sulphuric acid**. This is known as **acid rain**, and has effects like:

- (i) It kills the leaves of some species of plant (e.g. wheat).
- (ii) It makes the water of lakes acidic. This acidic water dissolves toxic chemicals (such as aluminium salts) present in the mud of the lake, which are insoluble in neutral or alkaline solutions. Fish, for example, are killed by aluminium.

Pollution due to insecticides

Insects can cause considerable harm to the economy, either as pests on crops or as vectors of disease. They can be killed very effectively by insecticides, but insecticides may pollute the environment, with the following harmful effects:

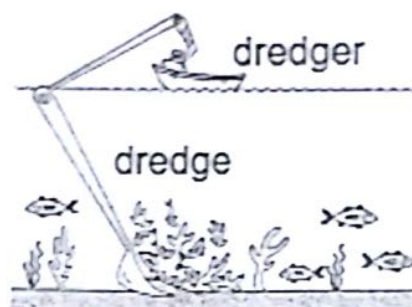
- (i) Useful insects, such as those needed for pollination, may be killed as well.
- (ii) If the livers of animals are unable to break down the insecticide, it may be passed from animal to animal along food chains. Animals at trophic level A eat many animals from trophic level B, and animals at trophic level B eat many animals from trophic level C (which may have been insects affected by insecticide). Therefore, animal A receives a very high, and perhaps very harmful, level of insecticides. For example, some birds are known to have been made sterile.
- (iii) Agricultural pesticides can be washed into rivers, entering food chains in the water as well as on land.

Uncontrolled fishing practices

Fish is an important **food source** for humans. As the human population increases, the **demand** for fish increases. Uncontrolled and unregulated fishing can result in **reduced aquatic biodiversity**. Fishing techniques that are detrimental to the aquatic environment involve the use of:

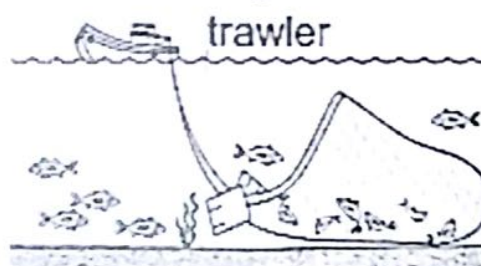
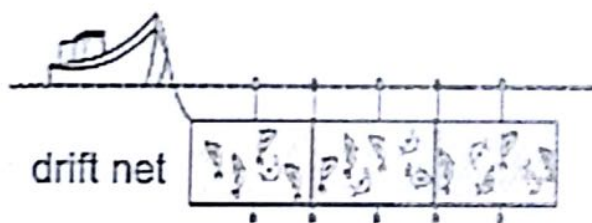
1. Dredges

Destroy coral reefs and organisms that live on the sea bed



2. Drift Nets and Trawlers

Catch marine life indiscriminately



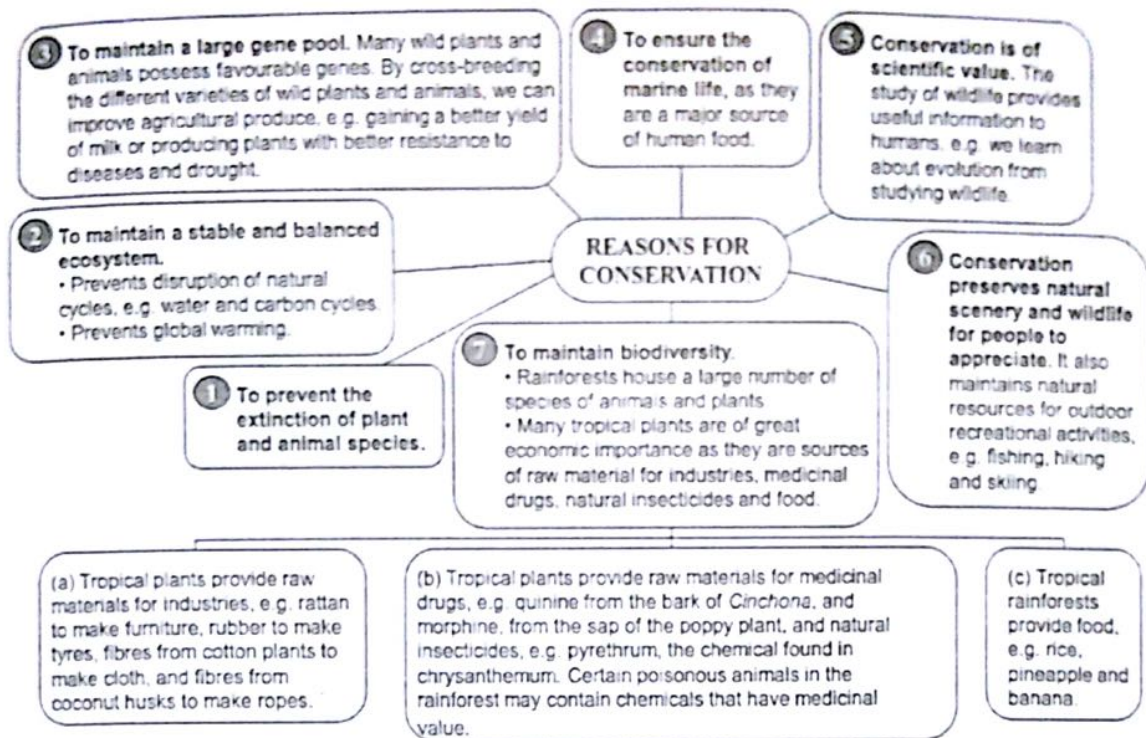
3. Cyanide Fishing

kills corals and other reef organisms.

Conservation

Human activities have depleted natural resources, polluted the environment and destroyed wildlife habitats. This threatens the **biodiversity** on Earth. **Biodiversity** is the range of species that is present in a particular ecosystem whereas **Conservation** is the protection and preservation of natural resources in the environment.

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Need of Conservation

The threat of extinction

The removal of organisms from an environment at a faster rate than the organism can reproduce itself leads to **extinction** of the species. Widespread deforestation can lead to the extinction of plant species; uncontrolled fishing can lead to the extinction of species of fish.

Destruction of habitats, however it may occur, may also lead to the extinction of **animal** species which live among the plants. Animals are protected by plants and are linked to them through food chains.

Plants are the source of many valuable products, such as the insecticide **pyrethrum** extract (from a species of daisy) and **drugs**. Aspiring (for pain relief and treatment of circulatory disorders), quinine (for the treatment of malaria) and many other drugs were first obtained from plants. Deforestation could rob humans of the plant which might bring a cure for diseases such as AIDS.

Conservation strategies

1. Forests

Timber, rubber and oils are commodities, or useful products, supplied by trees. Most trees that supply commodities grow very slowly; the product they supply may not be ready for harvest until many years after planting. A system of **sustainable management** must therefore be used. This means harvesting only the number of trees that can be replaced by planting. Forests can be managed to prevent the adverse effects of deforestation via:

- Creation of **laws** to regulate the logging industry
- **Reforestation**: The planting of new trees or seedlings to replace trees that have been destroyed
- Designation of lands as **forest reserves**
- **Research** to improve quality of forests and making them more productive

2. Fishing Grounds

The oceans supply many communities with a large part of their food requirements. **Overfishing** can reduce fish populations to a point where they are not able to maintain their numbers. Fishing **quotas** (a legally enforced limit on the amount of fish which can be caught) make sure that stocks remain at sustainable levels, but must be adhered to. Fishing grounds can be managed to prevent over-fishing and indiscriminate catches via:

- **Banning** the use of drift nets, trawlers and dredges
- Using nets with a certain **mesh size**
- **Limiting** the number of ships allowed in fishing grounds at any one time
- Raising endangered species of fish in **hatcheries** for release into the sea

Conservation of other species

To maintain the wide variety (**biodiversity**) of living species on the planet, it is important to identify **threatened species** so that their needs can be addressed before it is too late. This work is carried out by organizations such as the Worldwide Fund for Nature (WWF) and the Convention on International Trade in Endangered Species (CITES). Countries throughout the world must also support these organizations with legislation.

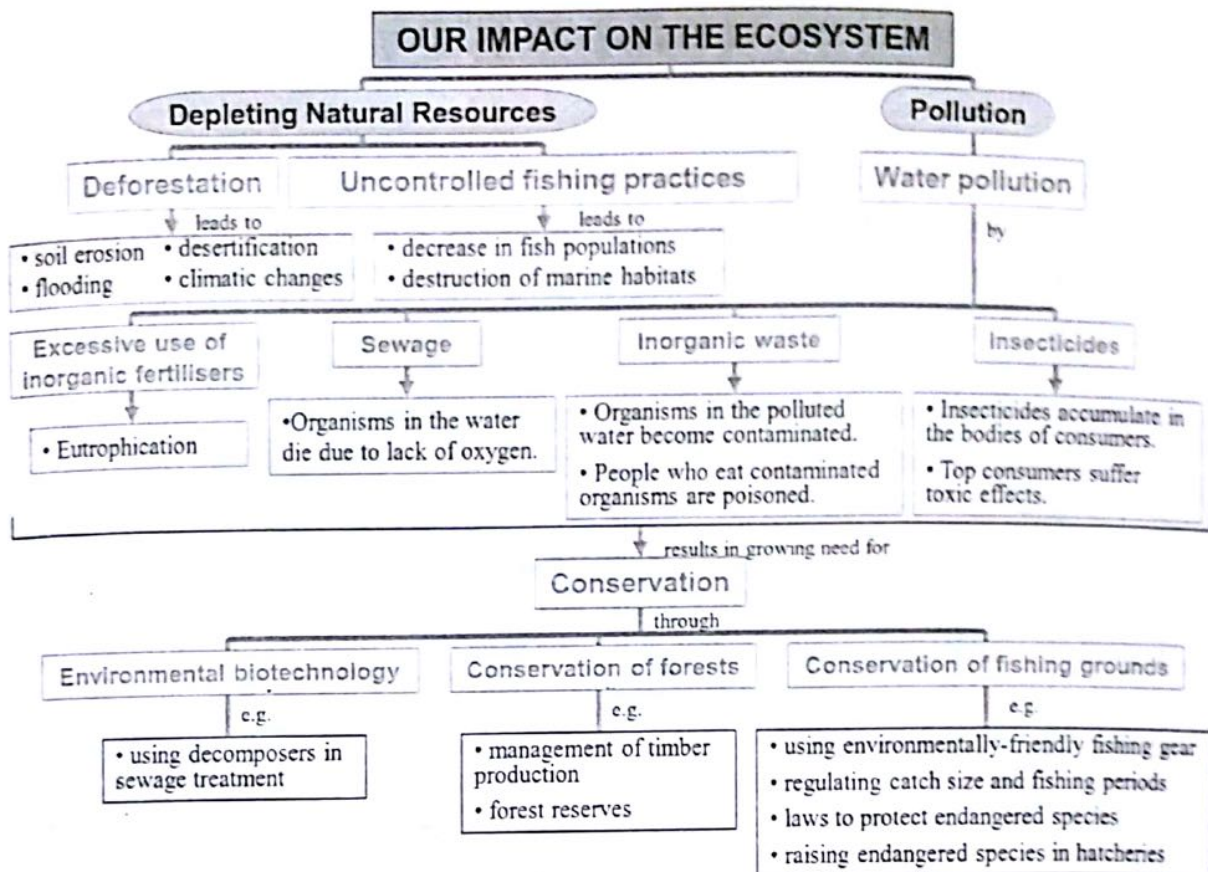
Recycling

Pressure is taken off endangered species if countries encourage a policy of **recycling**.

Many commodities we use every day can be recycled. For example:

- (i) Aluminium cans, tin cans and many car parts can be made of recycled **metal**. This reduces the need for mining activity and, consequently, the effect that mining has on the environment. The burning of fossil fuels, used to reproduce heat to extract metals from their ores, is also reduced.
- (ii) Bottles are made from recycled **glass**.
- (iii) **Paper** can be recycled so fewer trees need to be cut down for their **fibres** which are used to make paper products.
- (iv) **Litter** is also reduced by recycling, making our environment a more pleasant place in which to live. There is less need to bury garbage in landfills, or incinerate it.
- (v) When **sewage** is properly treated, it can be recycled to provide an effective fertiliser. The large amounts of water used to carry away the sewage, which would otherwise be wasted, can be purified even to the extent that it can be returned to drinking water supplies.

Concept Map



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Syllabus Check List Relationship of Organisms with one another and with

Environment

After reading chapter are you able to:

- ☐ state that the Sun is the principal source of energy input to biological systems
- ☐ describe the non-cyclical nature of energy flow
- ☐ define the following terms and establish the relationship of each in food webs:
 - producer – an organism that makes its own organic nutrients, usually using energy from sunlight through photosynthesis
 - consumer – an organism that gets its energy by feeding on other organisms
 - herbivore – an animal that obtains its energy by eating plants
 - carnivore – an animal that obtains its energy by eating other animals
 - decomposer – an organism that obtains its energy from dead or waste organic matter
 - food chain – a chart showing the flow of energy (food) from one organism to the next, beginning with the producer (e.g. mahogany tree → caterpillar → songbird → hawk)
- ☐ describe energy losses between trophic levels and infer the advantages of short food chains
- ☐ describe and interpret pyramids of numbers and of biomass
- ☐ describe and state the importance of the carbon cycle
- ☐ describe the nitrogen cycle in making available nitrogen for plant and animal protein, including the role of bacteria in nitrogen fixation, decomposition and nitrification (details of denitrification and the names of individual bacteria are not required)
- ☐ understand the role of the mosquito as a vector of disease
- ☐ describe the malarial pathogen as an example of a parasite and describe the transmission and control of the malarial pathogen (details of the life cycle of the pathogen are not required)
- ☐ describe the effects of humans on the ecosystem with emphasis on examples of international importance (tropical rainforests, oceans and important rivers)
- ☐ describe the consequences of deforestation in terms of its effects on soil stability, climate and local human populations
- ☐ evaluate the effects of:
 - water pollution by sewage, by inorganic waste and by nitrogen-containing fertilisers
 - air pollution by greenhouse gases (carbon dioxide and methane), contributing to global warming
 - air pollution by acidic gases (sulfur dioxide and oxides of nitrogen), contributing to acid rain
 - rain pollution due to insecticides
- ☐ discuss reasons for conservation of species with reference to maintenance of biodiversity.
- ☐ management of fisheries and management of timber production
- ☐ discuss reasons for recycling materials, with reference to named examples.

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O-LEVEL

BIOLOGY

Topic16:

**Development
of Organisms
and Continuity
of Life**

NOTES BY

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Syllabus 2017 – 2019

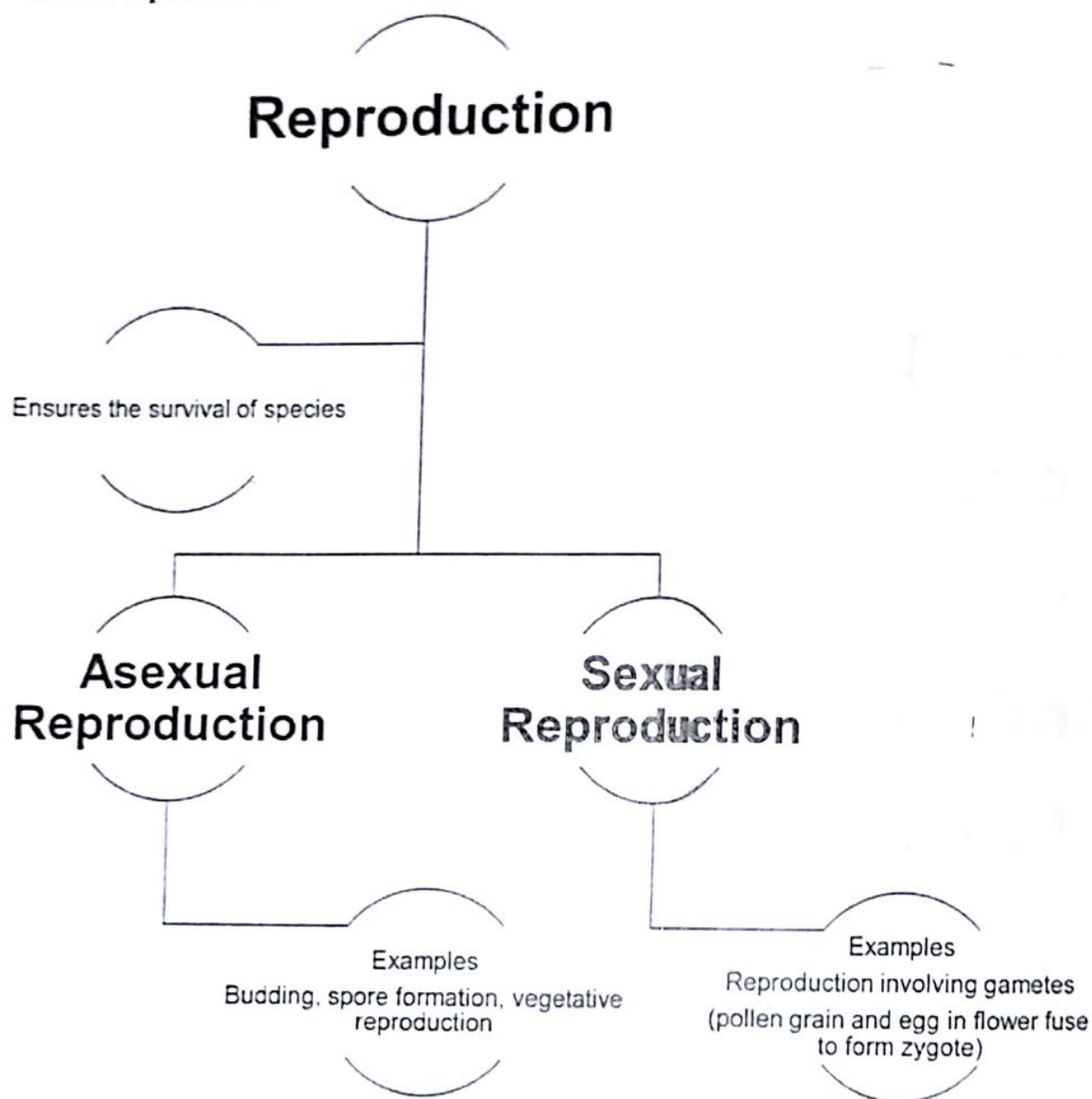
Content

- 16.1 Asexual reproduction
- 16.2 Sexual reproduction in plants
- 16.3 Sexual reproduction in humans
- 16.4 Sexually transmitted diseases

DEVELOPMENT OF ORGANISMS AND CONTINUITY OF LIFE

Reproduction in Plants

In living organism basically two types of reproduction is observed; sexual reproduction and asexual reproduction.



Comparison of Mitosis and Meiosis

Meiosis	Mitosis
Leads to production of gametes	Leads to the production of somatic cells (body cells)
Only half the chromosomes are passed on to the daughter cells, i.e. the haploid number of chromosomes	A full set of chromosomes is passed on to each daughter cell; this is the diploid number of chromosomes
Homologous chromosomes and their genes are randomly assorted between the gametes	The chromosomes and genes in each daughter cell are identical
New organisms produced by meiosis in sexual reproduction will show variations from each other and from their parents	If new organisms are produced by mitosis in asexual reproduction, they will all resemble each other and their parents; they are said to be 'clones'

Asexual Reproduction is the production of genetically identical offspring from one parent. A population of organisms produced in this way, and all genetically identical, is known as a **clone**.

The **advantages** of asexual reproduction are:

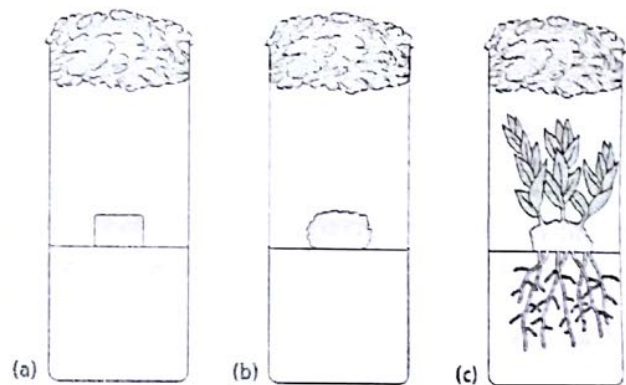
- (i) Only **one parent** organism is required.
- (ii) It is a relatively **certain method** of reproduction.
- (iii) Because the parent can survive in that particular habitat, the **genetically identical** offspring should be suited to the environment as well.
- (iv) **Commercially important** as produces **large number** of offspring and propagates **known characteristics** (such as flavor, appearance, yield and disease resistance).

The **disadvantages** of asexual reproduction are:

- (i) A lack of variation in offspring prevents evolution.
- (ii) Adverse conditions and disease will be likely to affect all members of the population.
- (iii) Overcrowding and competition for resources (water, nutrients and, importantly for plants, light).
- (iv) Distribution of the species is likely to be limited.

Tissue culture

A commercial application of asexual reproduction in plants is the use of a technique called tissue culture. **Tissue culture** is a technique for keeping alive cells or tissues of living organisms after their removal from an organism. Plants reproduced in this way include food plants (the **oil palm**, the **date palm** and the **banana**) and horticulture plants such as the **begonia**.



Demonstration

Method

Some actively dividing (**'meristematic'**) cells are taken from the parent plant, and placed on a sterilized **culture medium** in many separate sterilized dishes. The culture medium is a jelly-like substance called **agar** containing **plant growth hormones** and the ions necessary for healthy growth. The dishes are kept at a suitable temperature, and are covered to prevent the cells drying out.

Results

The cells continue to **divide**, then some of them become modified to produce small (**'adventitious'**) roots and some become modified to produce small shoots bearing lateral buds.

These plantlets can then be transferred to compost and will develop into clones of their parent.

The **commercial advantages** of using tissue culture to produce plants include:

- (i) it is **quick**
- (ii) it is **reliable**
- (iii) it gives plants of **guaranteed type**
- (iv) it is **profitable**

Sexual reproduction

Sexual reproduction is the fusion of male and female nuclei to form a zygote. Zygotes develop into offspring genetically different from each other, and from their parents. The nuclei are contained within **gametes**. As a result of a special type of nuclear division ('**reduction division**'), the nuclei of gametes contain only **half** the number of chromosomes found in normal body cells.

Sexual reproduction in plants

The **flowers** of plants are the organs of sexual reproduction. Flowers have the following parts:

1. Sepals

Sepals are (usually) green, leaf-like structures which protect the flower when it is in bud.

2. Petals

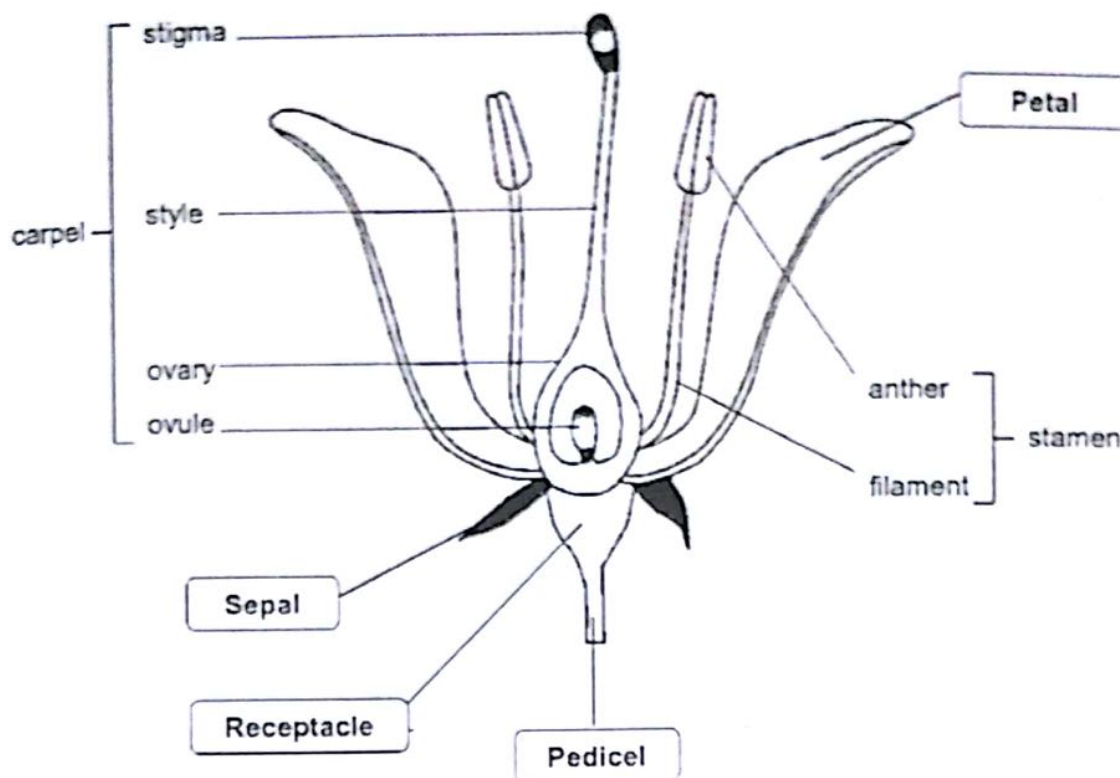
Petals may be large, colorful and scented with lines on them (nectar guides) if the flower is pollinated by insects. But if the flower is wind-pollinated, the petals are small and green, or not present at all.

3. Anthers

Anthers contain **pollen sacs** which make and then release **pollen grains**. Each pollen grain contains the male gamete(s). An anther is situated at the end of a stalk-like **filament** – an anther and a filament together form a **stamen**. Stamen is the male part of the flower.

4. Carpels

Carpels are the **female** part of the flower. Each carpel is made up of a (sticky) **stigma** (for receiving pollen during pollination), connected by a **style** to the **ovary**, in which lie the **ovules** which contain the female gamete.



Pollination

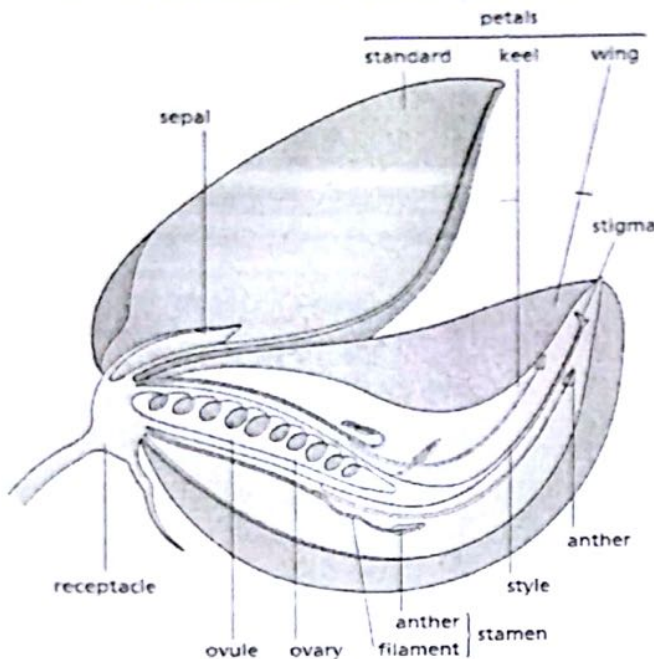
Pollination is the transfer of pollen from an anther to a stigma. Pollination is of two types. **Self-pollination** occurs when the anther and stigma are either in the same flower, or in different flowers **on the same plant** whereas **Cross-pollination** occurs when the anther and stigma are in flowers on **different plants of the same species**.

The two most common agents for carrying pollen are the **wind**, and **insects**. Wind and insect-pollinated flowers have structural differences, adapted according to their method of pollination.

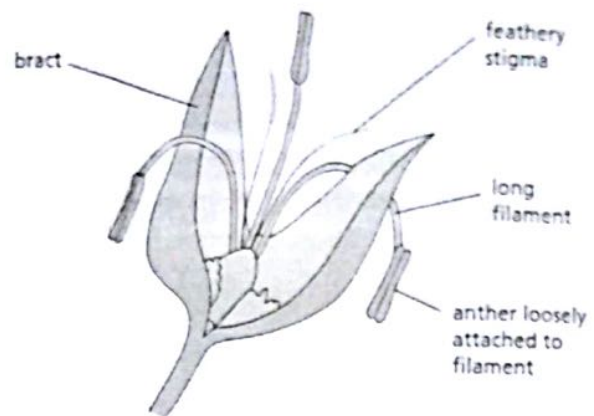
The differences between wind and insect-pollinated flowers

Structure	Wind-pollinated flowers	Insect-pollinated flowers
Petals	Smaller or absent No scent Nectar guides absent Nectar absent	*Larger colorful Scented Nectar guides present Nectar present to attract insects (* also act as landing platforms)
Pollen grains	Smaller Dry and dusty Smooth-coated Light More easily carried by the wind Vast quantities (greater wastage of pollen)	Larger Sticky Rough-coated Relatively heavy More easily carried by insects Smaller quantities (pollination much more certain)
Anthers	Held outside the flower in the wind	Protected within the flower where insects will touch them
	Relatively large	Relatively small
Stigmas	Large surface area Outside flower	Small surface area Insider flower

Examples of wind-pollinated flowers are **maize** and **grasses**. Examples of insect-pollinated flowers are **beans** and **black-eyed Susan**.



An Insect pollinated flower



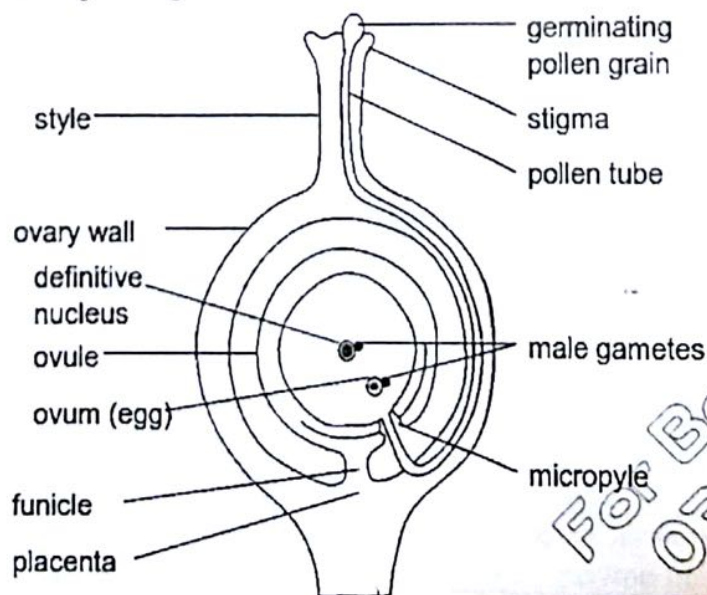
A wind pollinated flower

Fertilization in flowering plants

When the pollen grain arrives on the stigma of the **correct** species of plant, the sugary solution on the stigma forms a medium in which the pollen grain will **germinated**. Germination of the pollen grain involves the growth of a **pollen tube**, which releases **enzymes** at its tip in order to **digest** the cells of the style beneath. In this way, the cells of the style are removed to allow the pollen tube to **grow** down the **style** towards the **ovary**.

On arrival at the ovary, the end of the pollen tube enters an **ovule** through a small hole called the **micropyle**. Inside the ovule is the **embryo sac** which contains the female **gamete**, within which is the female **nucleus**.

The end of the pollen tube then bursts to release the **male gamete**, which has travelled down the pollen tube from the pollen grain. **Fertilisation** occurs as the **nuclei of the male and female gametes fuse**.

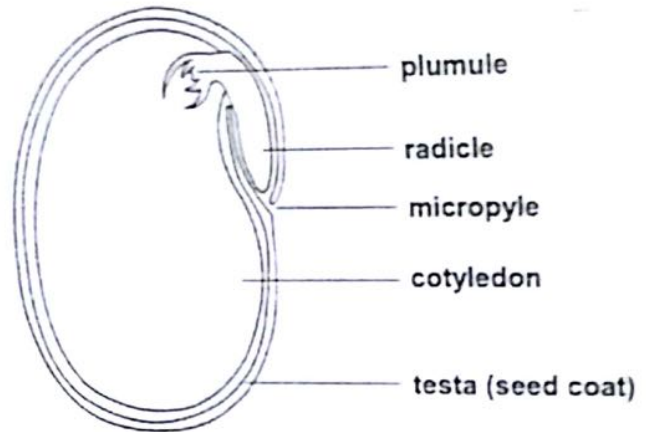


The development of the fruit

Once fertilisation has occurred, the ovule is then called a **seed**. The ovary wall then becomes the **pericarp**, and the (protective) pericarp with the seed(s) inside is called the **fruit**.

Seed structure

Sugars and amino acids travel through the phloem of the parent plant, and enter the seed. Sugars are converted to starch and, in some cases, fat (e.g. the sunflower). Amino acids are converted to protein. **Starch and protein** are then **stored** in the seeds of dicotyledonous plants in two large storage organs called **cotyledons**. Between the two cotyledons lies the **plumule** (or young shoot) and the **radicle** (young root) of the embryo plant. The **embryo** within the seed of a



dicotyledonous plant is made up of **cotyledons**, **plumule** and **radicle**. The embryo is protected within a seed coat or **testa**.

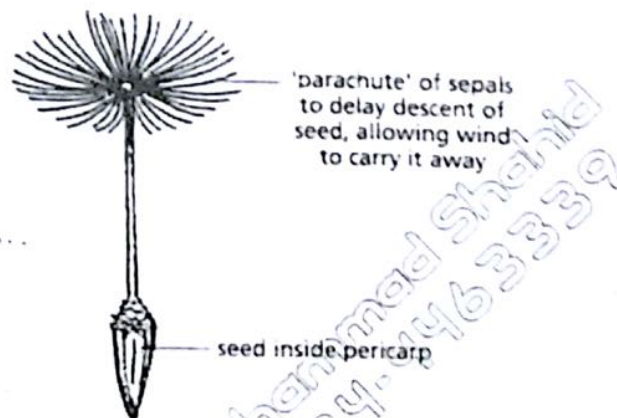
Seed dispersal

Once it has developed within the fruit, the seed containing the embryo plant must break free from the parent and be **dispersed**. In this way, the plant species is able to **colonize new areas**. It also **prevents overcrowding** and **avoids competition** with its fellow offspring for light and for nutrients.

It may be some time before the embryo is in a suitable environment for growth. The food stored in the cotyledons will keep it alive. However, many seeds never find a suitable environment and there is great wastage. There are two main agents of dispersal responsible for carrying away the seed (often still part of a fruit and still inside its pericarp): **wind** and **animals**.

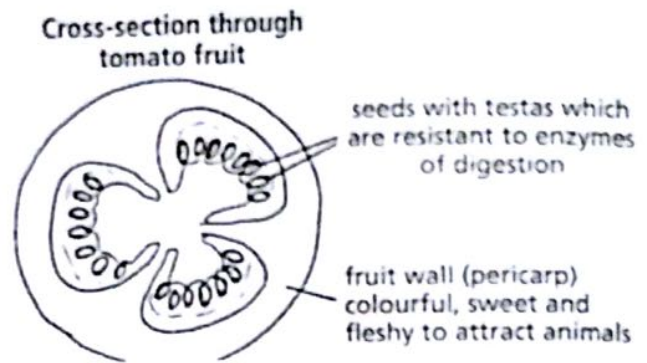
Wind-dispersed seeds (or fruits) are usually:

- (i) light in weight, and
- (ii) have their testa (if it is a seed) or pericarp (if it is a fruit) extended to provide a **large surface area**. This allows the seed or fruit to catch in the wind and be pulled clear of the parent. It also slows the seed's fall to the ground, allowing the wind to carry it some considerable distance away.



Animal-dispersed seeds may rely on coloured, sweet and juicy pericarps around them to induce an animal (often a bird) to eat them. In this case, the seeds will also have enzyme-resistant testas, so that they can pass through the animal's intestines intact. They will then be dropped in the animal's faeces at a distance from the parent plant.

Sometimes animal-dispersed seeds or fruits are dry, with hooks on their testas or on the surrounding pericarps. The hooks catch on a small mammal's fur and the seeds or fruits are carried some distance before being removed.



Germination of seeds

When suitable environmental conditions are available, the seed will **germinate**. The conditions necessary for seed germination are:

- (i) **Water** (to activate the enzymes).
- (ii) **Oxygen** (to allow for the release of a great deal of energy from respiration to fuel the greatly increased growth rate).
- (iii) **A suitable temperature** (enzymes operate efficiently only if the temperature is suitable for them).

Remember: Light is not necessary for seed germination.

If conditions are suitable, the enzymes work to digest the food stored in the cotyledons. The food is then carried to the **growing regions** of the embryo.

Demonstration

The need for the conditions needed for germination of seeds can be demonstrated experimentally, as follows:

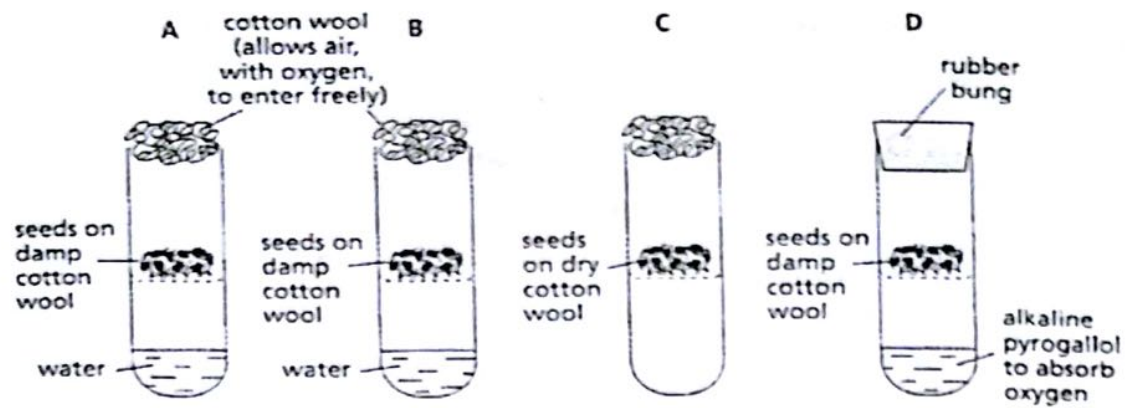
Apparatus

- four test-tubes
- cotton wool
- rubber bung
- ignition tube
- alkaline pyrogallol
- cotton
- dry seeds (e.g. green beans)

Method

Set up the experiment as shown in the diagram below, and leave the test-tubes for two to four days.

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- A. The Control. Seeds left in air at room temperature (a suitable temperature for germination).
 B. Seeds left in refrigerator (4°C) – not a suitable temperature for germination.
 C. Seeds left in air at room temperature.
 D. Seeds left at room temperature.

Results

Only the seeds in tube A, which has access to all the three conditions (room temperature, water and oxygen), will germinate.

Conclusion

A **suitable temperature**, **water** and **oxygen** are all necessary for seed germination.

The use of enzymes in the germination of seeds

Food is stored in seeds in the form of **large, insoluble, organic** molecules, either in **cotyledons**, or (in monocotyledonous seeds) in a special storage tissue called **endosperm**. These large molecules are usually:

- (i) **carbohydrate** (usually in the form of starch)
- (ii) **protein**, and sometimes
- (iii) **fat**.

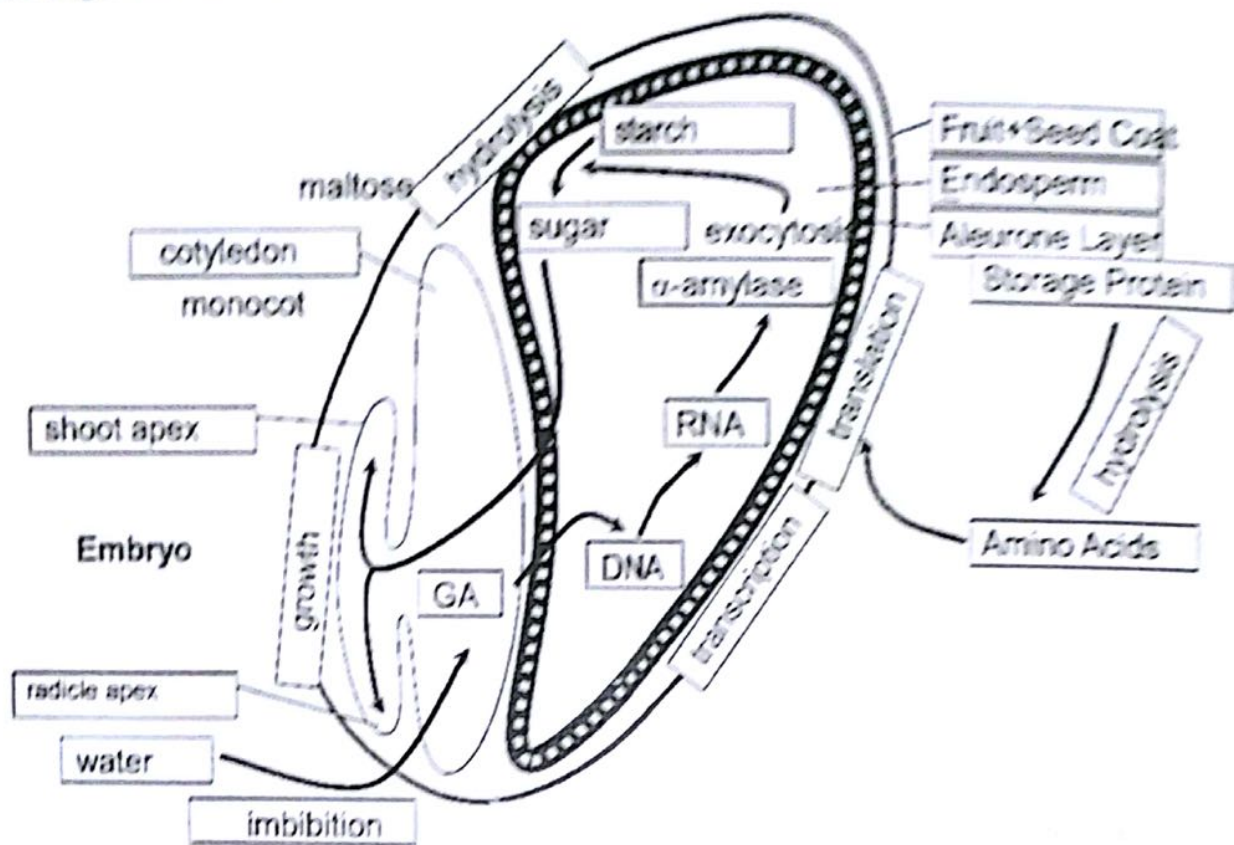
When a seed germinates, these food stores must be changed into smaller molecules. These molecules must be able to dissolve in the water which has been absorbed by the seed. They are then transported, **in solution**, to the **growing regions** of the seedling to make new cells. **Enzymes**, present in the seeds and activated by the absorbed water, bring about these chemical conversions.

Substrate	Enzyme	Product
Starch	Amylase	Glucose
Protein	Protease	Amino acids
Fats	Lipase	Fatty acids and glycerol

The **glucose** is used in **respiration** to provide the **energy** for the process of growth. The **amino acids** are used to build up **proteins** in the **cytoplasm of the new cells**. The **fatty acids** and **glycerol** recombine to form **fats** which are used to make important components of cell membranes. Fats also provide a considerable amount of **energy**.

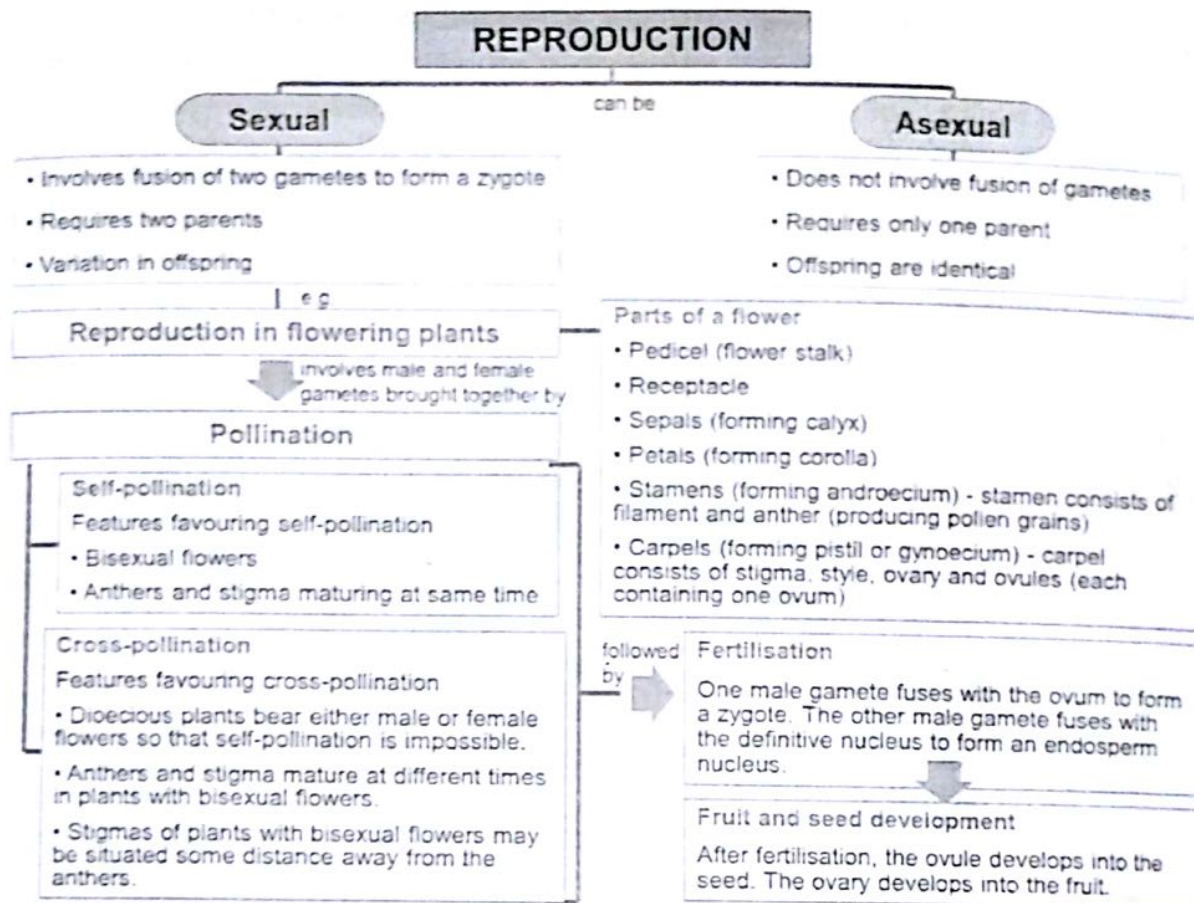
The enzymes shown in the table above, like many other enzymes, work by digesting larger molecules. In this process, molecules of water are used to split (or **hydrolyze**) large **substrate**

molecules into smaller **product** molecules. The enzymes are said to bring about hydrolysis of the larger molecules.



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Concept Map



Reproduction in Humans Beings

Although a baby is born with a full set of reproductive organs, these organs are not functional during the first 12 years of life. Under the influence of **hormones** from the **pituitary gland**, the organs become active at the time known as **puberty**.

The male reproductive system

The male nuclei involved in the process of human sexual reproduction are located within male **gametes** (sex cells) called **sperms**. The male reproductive system is designed to manufacture sperms and to deliver them to the place where one of them will be able to fuse with a female nucleus.

Testes (singular: 'testis')

The testes are the **gonads** of the male. Gonads are the organs which produce the gametes, in this case the sperms. The testes are made of millions of tiny coiled tubes. The cells forming the walls of these tubes are constantly dividing to produce up to 100,000,000 sperms per day. The testes work more efficiently at just below body temperature, so they are held outside the body in the **scrotum** (or scrotal sac).

Sperm ducts

Sperm ducts are tubes which carry the sperms away from the testes. They join with one another and with the tube bringing urine, at a position just under the bladder. Each sperm duct bears a **seminal vesicle** for sperm storage.

Prostate gland

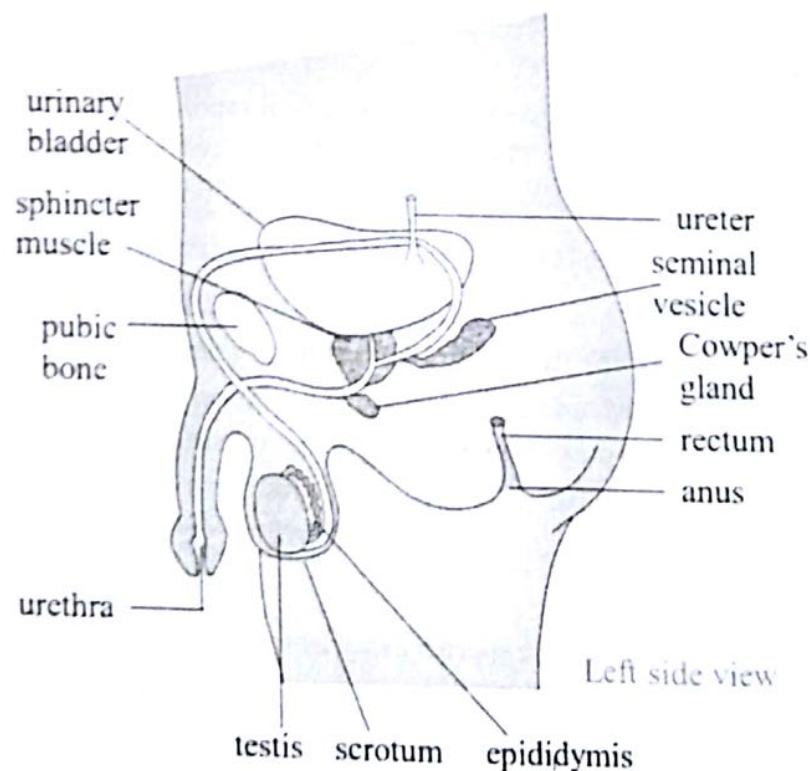
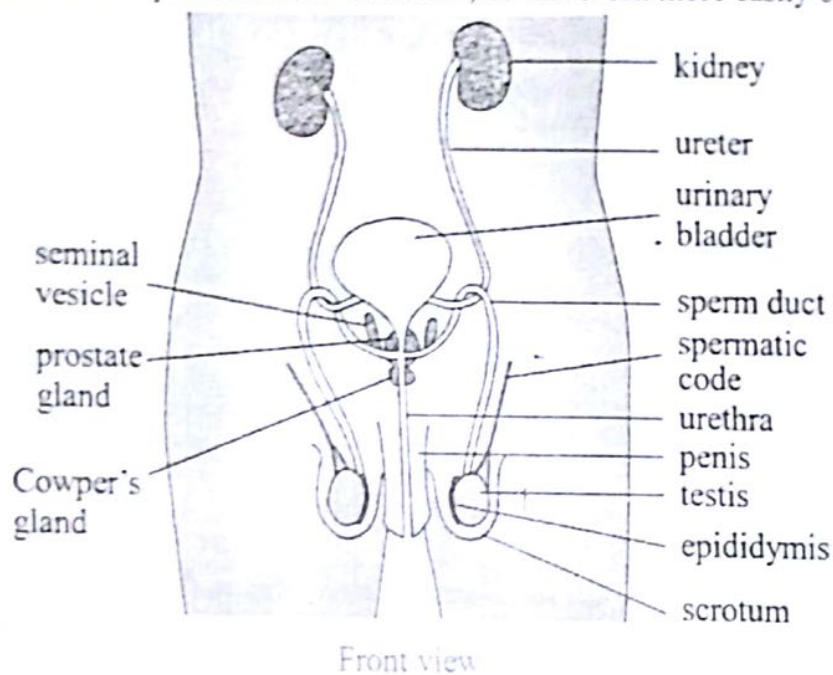
The prostate gland is about the size of a golf ball. It surrounds the junction between the sperm ducts and the tube from the bladder. It manufactures, and adds to the sperms, a nutrient fluid (**seminal fluid**) in which the sperms are able to swim (sperms + seminal fluid = **semen**).

Urethra

The urethra is a tube that carries both urine and semen along the **penis** to be released from the body.

Penis

The penis is the organ for introducing sperms into the female. It contains spongy tissue which fills with blood to make the penis firm (an 'erection') so that it can more easily be guided into the female.



The female reproductive system

The female nuclei which are involved in the process of sexual reproduction are located in the female **gametes** called **ova** (singular: '**ovum**'). The functions of the female reproductive system is to produce ova and ensure that they are fertilized by the male gametes and to protect and nourish the embryo until it is born.

Ovaries

The ovaries are the female **gonads**, making and releasing the female gametes (ova). There are two ovaries, each a little smaller than a ping-pong ball, lying in the lower abdomen. The female releases one ovum every four weeks from alternate ovaries, that is, each ovary releases one ovum every **eight weeks**.

Oviducts

The oviducts are the tubes which carry the ova away from the ovaries. They are lined with cilia which, together with a little muscular assistance, help to move the ova gently along. If fertilisation occurs, it usually does so about **one-third** of the way along the oviduct.

Uterus

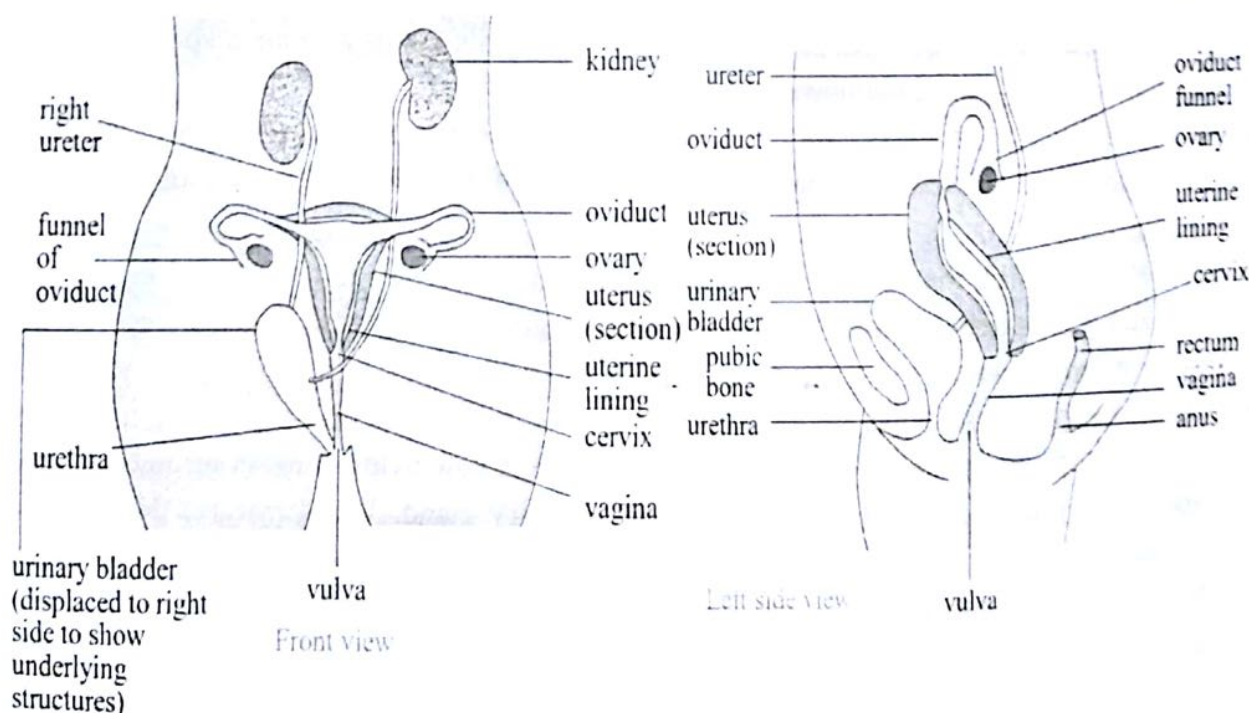
The uterus is a **pear-shaped** organ lying behind and slightly above the bladder. Its walls contain **involuntary muscle** (muscle that cannot be consciously controlled). The embryo develops in the uterus during **pregnancy**.

Cervix

The cervix is the 'neck' of the uterus, where the uterus joins the vagina. It supplies mucus to the vagina.

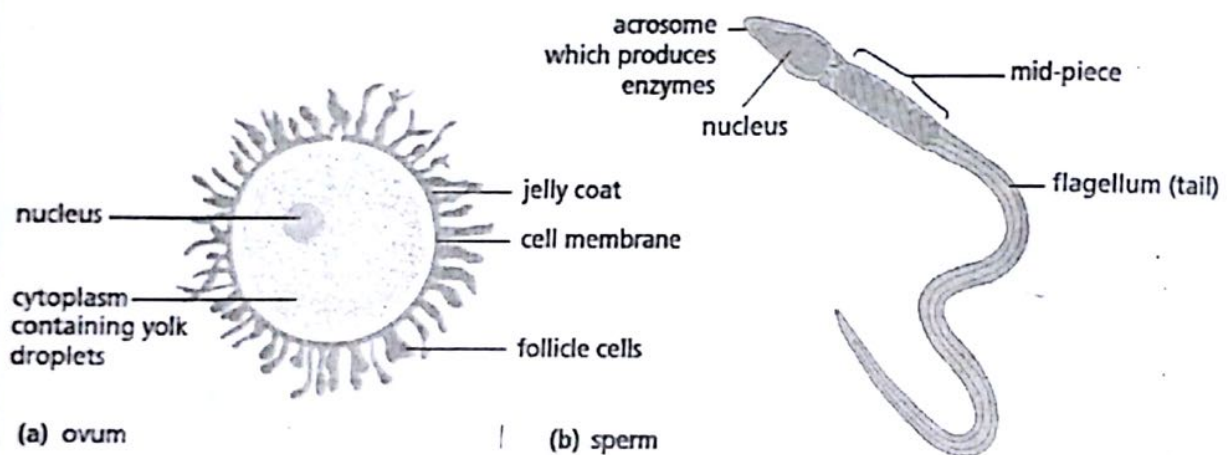
Vagina

The vagina is the part of the female system which receives the penis during **copulation**. It is muscular and stretchable (it forms part of the birth canal) and it connects the cervix with the slit-like **vulva** opening to the outside.



A comparison of male and female gametes

Male gametes	Female gametes
Released in millions	Released one at a time
Able to move	Unable to move on their own
Very small (0.05 mm – of which around 80% is tail)	Comparatively large (0.1 mm in diameter)
Very little cytoplasm	A lot of cytoplasm which contains nourishment for the zygote if the ovum is fertilised
Nucleus contains either an X or a Y chromosome	Nucleus always contains an X chromosome



The menstrual cycle

Once a female reaches puberty, she will start to release ova from her ovaries (i.e. she will start to **ovulate**). Ovulation is one stage in her **menstrual** or **monthly cycle**, described below:

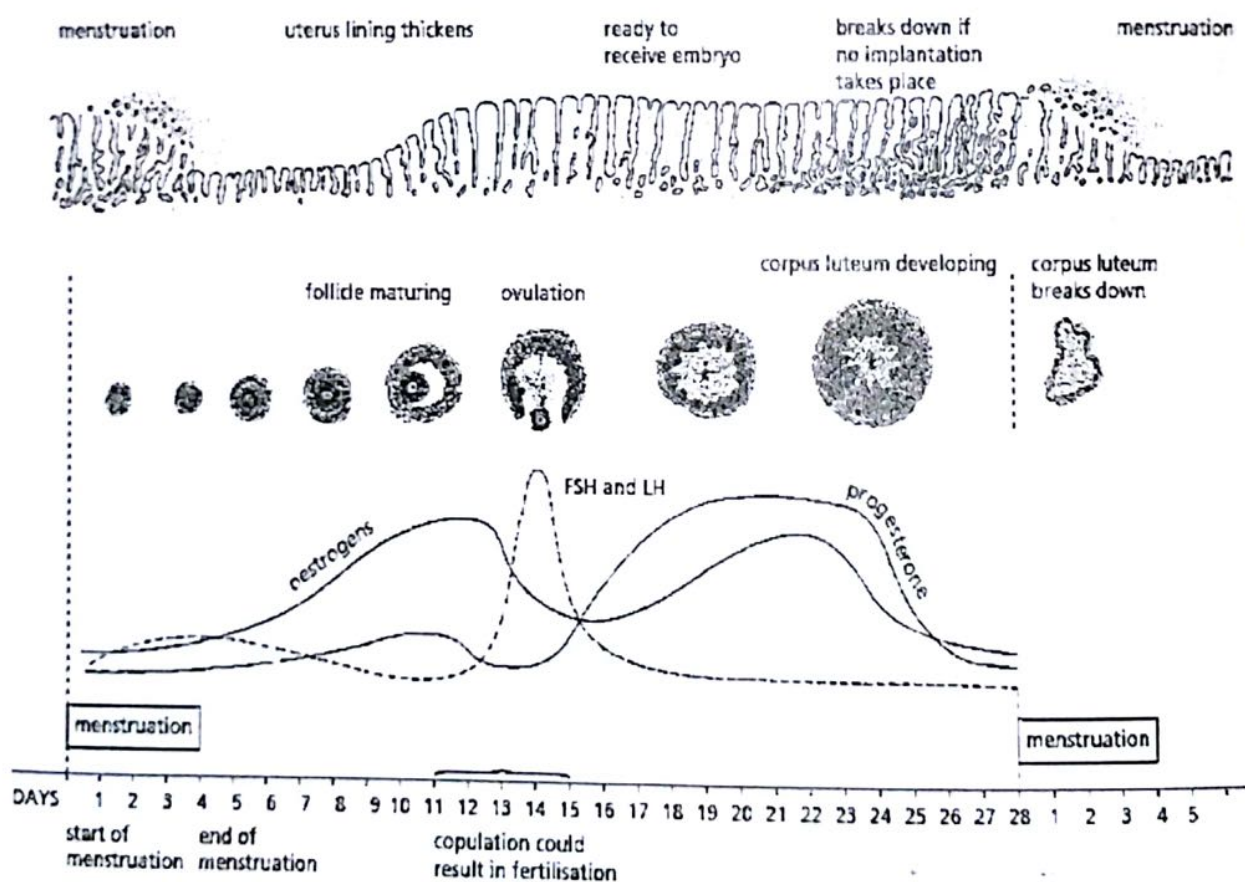
1. Over a period of about 14 days, the walls of the female's uterus develop a **spongy lining**, containing many blood capillaries.
2. When the spongy lining is ready, ovulation occurs. The ovum passes down the oviduct. If the ovum is not fertilized by a sperm, it passes through the uterus and vagina and out of the vulva.
3. The spongy lining then peels away from the uterus wall, damaging the blood capillaries. The lining is passed out of the vagina and vulva, together with blood. This is **menstruation** or the **monthly period**. Menstruation lasts for about four days.
4. Once the uterus wall has recovered, it begins to rebuild its spongy lining, under the influence of a hormone from the ovary. Meanwhile, a new ovum is maturing in the ovary, under the influence of a hormone from the pituitary gland. When mature, the ovum is released (ovulation), at around two weeks after menstruation. The cycle continues in this way as long as the female remains healthy.

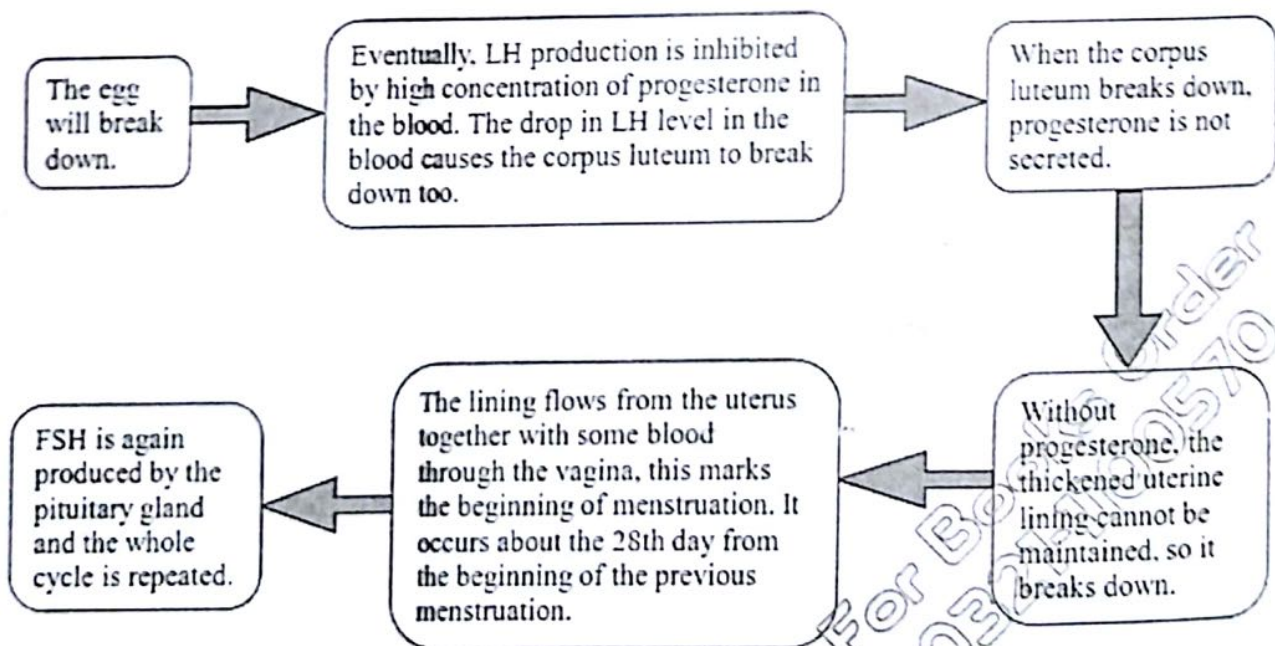
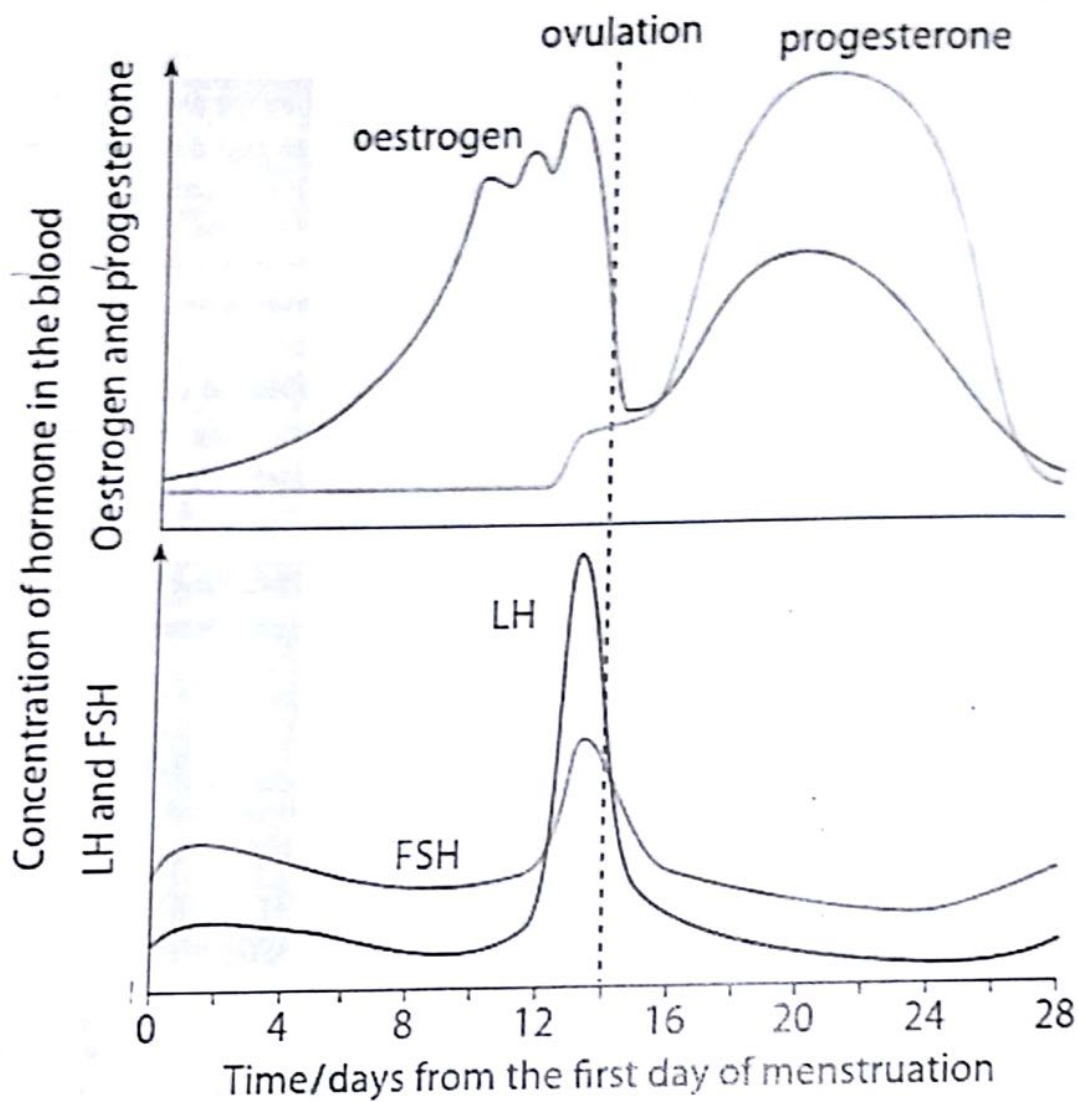
Hormones and Menstrual Cycle

At the start of the cycle, the lining of the uterus wall has broken down (**menstruation**). As each **follicle** in the ovaries develops, the amount of **oestrogen** produced by the ovary increases. The oestrogen act on the uterus and cause its lining to become thicker and develop more blood vessels. These are changes that help an early embryo to implant.

Two hormones, produced by the pituitary gland at the base of the brain, promote ovulation. The hormones are **follicle-stimulating hormone (FSH)** and **luteinizing hormone (LH)**. They act on a ripe follicle and stimulate maturation and release of the ovum. Once the ovum has been released, the follicle that produced it develops into a solid body called the corpus luteum. This produces a hormone called **progesterone**, which affects the uterus lining in the same way as the oestrogen, making it grow thicker and produce more blood vessels.

If the ovum is fertilised, the corpus luteum continues to release progesterone and so keeps the uterus in a state suitable for implantation. If the ovum is not fertilised, the corpus luteum stops producing progesterone. As a result, the thickened lining of the uterus breaks down and loses blood, which escapes through the cervix and vagina.





If fertilization takes place

The fertilised egg becomes a zygote.
The zygote develops into an embryo.

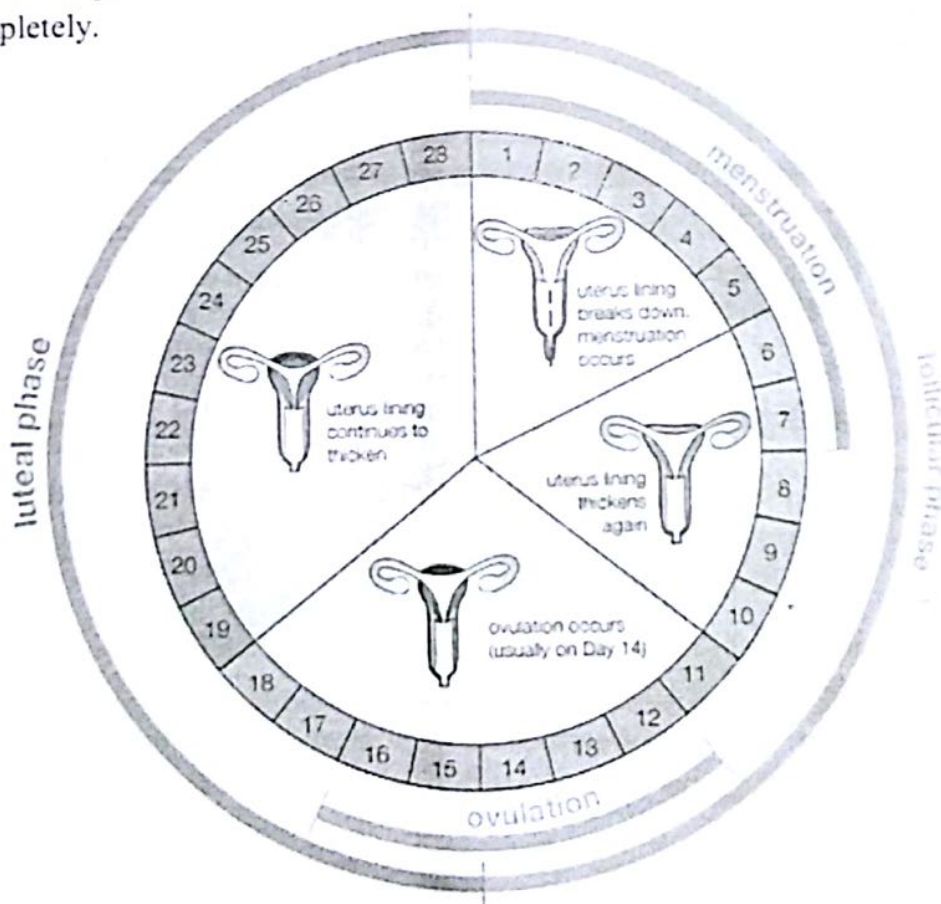
The embryo secretes a hormone which prevents the corpus luteum from breaking down until a structure called the placenta is formed. The corpus luteum continues to secrete progesterone and oestrogen until the placenta is able to take over the production of progesterone and oestrogen.

The embryo embeds itself in the uterine lining.

If an ovum is fertilized, and the woman becomes pregnant, her menstrual cycle stops until after the baby is born. When a female reaches the **menopause**, usually at around 50 years of age, she stops ovulating and can no longer become pregnant.

Factors affecting the menstrual cycle

- **Stress** – At times of emotional stress the menstrual cycle may become irregular.
- **Diet** – An inadequate diet can lead to an irregular cycle, and starvation can suppress the cycle completely.



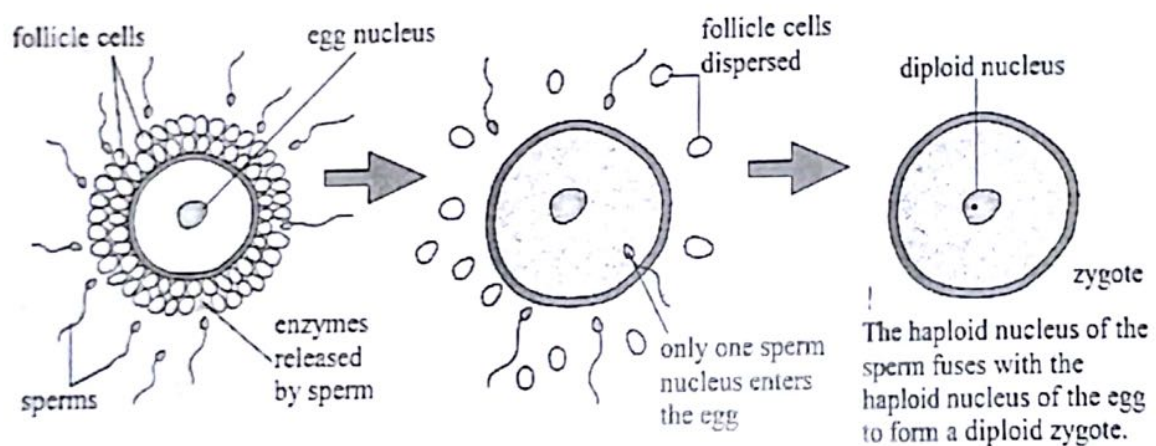
Fertile and infertile phases of the menstrual cycle

When there is no ovum in the oviducts, fertilisation cannot occur. It is unlikely to occur if the ovum is not in the correct position in the oviduct, however, sperms can live in the oviduct for a few days, allowing the ovum a chance to arrive. A woman's **most fertile period** is therefore **from a few days before ovulation** (allowing for the possible survival of sperms in the oviduct) **to a few days after ovulation**. Outside this time, she is less likely to become pregnant.

Human fertilisation

During copulation, sensitive cells near the end (glans) of the penis are the receptors for a **reflex** action leading to the release (**ejaculation**) of semen. The sperms are deposited near the cervix of the female, then swim through the uterus and up the oviducts. If they meet an ovum, around one-third of its way from the ovary, **one** of the sperms may fuse with the ovum to form a **zygote**. This is the moment of **fertilisation**.

The egg released from the ovary is usually surrounded by a few layers of follicle cells.



① To penetrate the egg, the acrosome of the sperm releases an enzyme to disperse the follicle cells and break down part of the egg membranes for the sperm to enter.

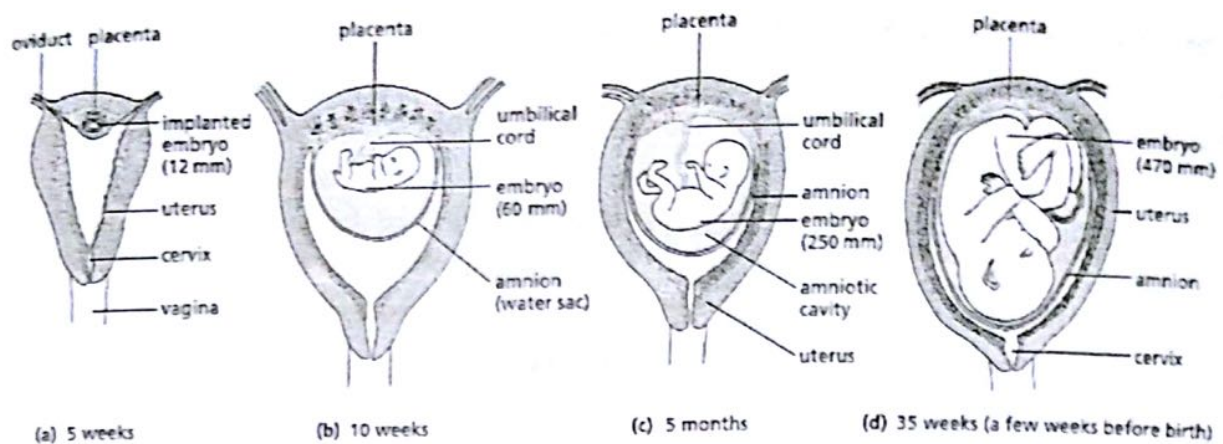
② Only one sperm nucleus enters the egg. The haploid sperm nucleus fuses with the haploid egg nucleus, and a fertilised egg or diploid zygote is formed.

③ As soon as the sperm has entered the egg, the membrane of the egg changes so that no other sperms can enter. The remaining sperms, which do not fertilise the egg, eventually die.

Development of the embryo

The zygote, a single cell formed from equal nuclear contributions from both parents, now begins to divide, eventually to form a **hollow ball of cells**. This stage in embryonic development is called the **blastocyst**.

The embryo initially absorbs nourishment secreted by the cells of the uterus, but it soon embeds itself (**implantation**) in the spongy lining of the uterus. Further division of the cells turns the blastocyst into a **fetus**. The fetus is surrounded by a membrane (the **amnion**) which forms the amniotic sac enclosing the fetus in a water bath (the **amniotic fluid**).



Functions of the amniotic fluid

- To protect the embryo from physical damage, e.g. if mother falls over.
- To support the embryo, keeping even pressure all around it, allowing organs to develop without restriction.
- To allow the fetus some restricted movement.

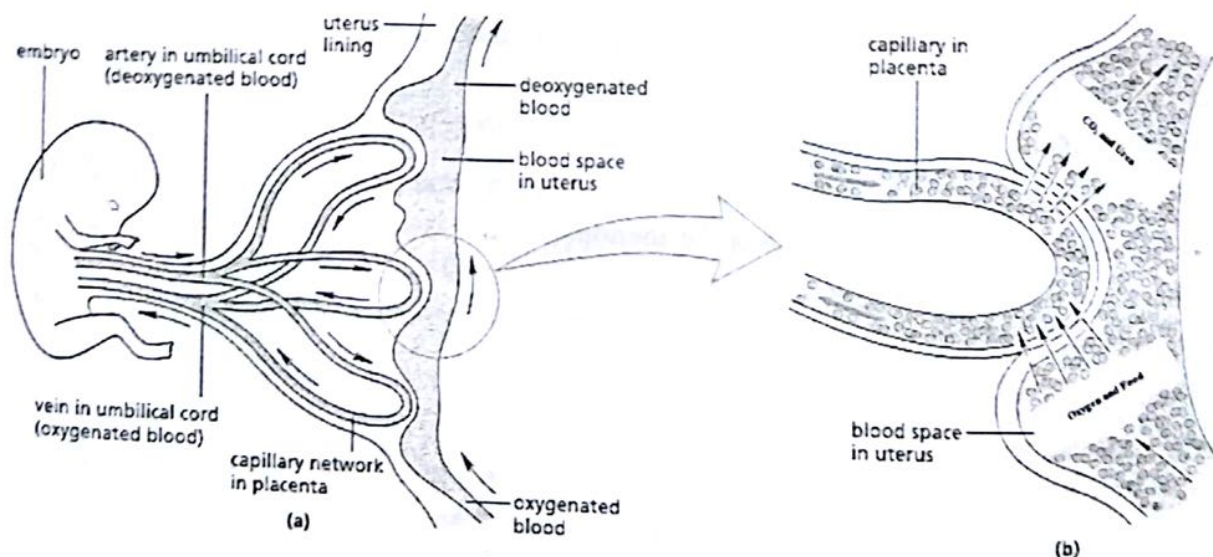
The nutrition and excretion of the fetus

Both nutrition and excretion are carried out through a special structure called the **placenta**. This is made up partly of material from the fetus, and partly of material from the spongy lining of the uterus. In the placenta, **blood** in the mother's capillaries runs **very close** to blood in the capillaries of the fetus. However, their blood **does not mix** – mother and child may be different blood groups.

Diffusion of substances takes place between the two blood systems.

Diffusing from mother to fetus	Diffusing from fetus to mother
Dissolved nutrients: Glucose, Amino acids, Ions, Vitamins, Water	Nitrogenous waste: Urea
Dissolved gas: Oxygen	Dissolved gas: Carbon dioxide

The placenta is connected to the fetus by the **umbilical cord**, inside which run **fetal blood vessels**. The umbilical **vein** brings substances to the fetus; the umbilical **artery** carries substances **from** the fetus.



The dietary needs of a pregnant woman

An embryo's development depends on the food eaten by its mother, so a pregnant woman must adjust her diet accordingly. She needs to ensure that the **levels** of the following constituents are higher than in her normal intake:

- (i) **Protein*** for the manufacture of embryonic tissues.
- (ii) **Carbohydrate*** for additional respiration in embryonic tissues.
- (iii) **Vitamin C** for making proteins in the embryo.
- (iv) **Vitamin D and calcium** for making bones and teeth of embryo.
- (v) **Iron** for making embryo's blood.

* These should be raised to the approximated levels **required** by a very active woman who is not pregnant.

The value of breast feeding

After the birth of the baby, **milk** from the mother's **mammary glands** supplies the ideal food for the first months of development. Breast feeding **also helps** to develop the bond between mother and baby. Except for all this mother's milk:

- (i) is **freely and readily** available
- (ii) contains all the necessary **constituents**, in the **correct proportions**
- (iii) is at the **correct temperature**
- (iv) contains some **antibodies** which protect the baby **against** disease.

Some babies may suffer harmful reactions to the **substitute** formula milk powders which are used in bottle feeding.

Birth control

The world population has risen alarmingly over the **last few** decades. It is already difficult to supply enough food to all areas of the world. A **solution** lies in **birth control**. The main methods are:

1. 'Natural' method (or rhythm method)

Sexual intercourse (copulation) is limited only to **those times** in the menstrual cycle when fertilisation is less likely.

However, a woman's menstrual pattern may not be a **reliable** indicator of her fertility. Severe **anxiety** and **malnutrition** can **suppress** the **menstrual cycle completely**. Varying degrees of anxiety and dietary deficiency can lead to an erratic **menstrual** pattern.

Not all healthy and perfectly happy women have **predictable** and regular periods – particularly when **teenagers** or when approaching the **menopause**. **Often** the most accurate prediction can only be that ovulation usually occurs somewhere **between 12 and 16 days** before the start of menstruation. The 'natural' method of birth control is **therefore** not a **reliable** method of avoiding pregnancy.

2. Chemical method

Chemicals which kill sperms ('**spermicides**') are put **into** the **vagina** of the female before intercourse. This is not a very effective method of **birth control** when used on its own.

3. Mechanical methods

- Where some form of **barrier** is put between the sperms and the ova. The barrier may take the form of:
 - a **condom**, a sheath placed over the penis before intercourse to catch the sperms when ejaculated
 - a **femidom** which lines the vagina of the female with the same result
 - a **diaphragm** which fits over the cervix of the uterus, preventing the entry of sperms. A diaphragm is usually used with a spermicide.

Barrier methods are popular and quite effective.

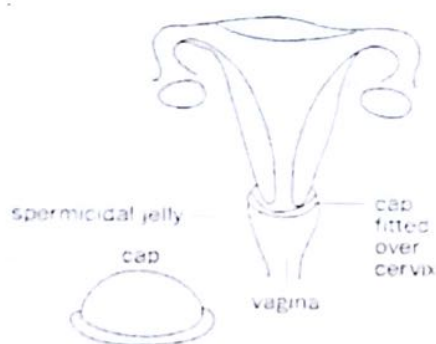
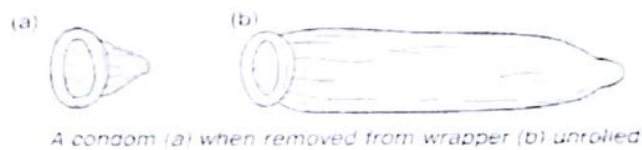
- Where there is **no** barrier between the sperms and the ovum:
 - an **intra-uterine device (IUD)** which is fitted inside the uterus. It does not stop fertilisation, but it prevents implantation of the blastocyst. This is an effective method of birth control.

4. Hormonal method

This method is otherwise known as **the pill**. The **woman** takes a tablet which contains a hormone. When taken **regularly**, the pill prevents ovulation, so that no ova are present to be fertilised. This is an effective method of birth control if the routine is followed carefully.

5. Surgical methods

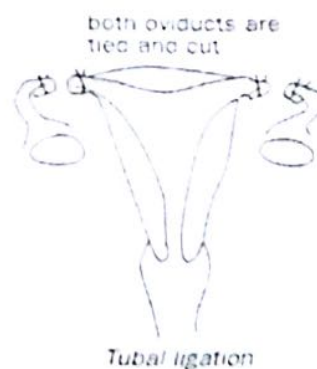
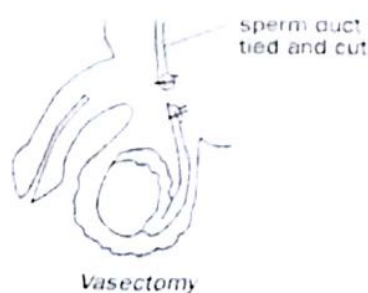
- In the **male**: cutting the sperm ducts (the operation is called **vasectomy**) – an effective method but rarely reversible.
- In the **female**: tying the oviducts to prevent the passage of ova – an effective method and usually reversible.



The cap or diaphragm



Intra-uterine devices (IUDs)



Sexually transmitted disease

During the act of sexual intercourse, the bodies of the partners are brought into close contact. **Pathogens** can easily pass from one infected person to another. Diseases spread through sexual contact are called sexually transmitted diseases (STDs). Three examples are **syphilis**, **AIDS** and **gonorrhea**.

Syphilis

Syphilis is caused by a **bacterium**. Symptoms of the disease include: sores on the penis, or around the vulva, a slightly raised temperature, rash and headache. This disease can eventually destroy the tissues of the brain, skeleton and other major organs. However, it may be treated with antibiotics.

Syphilis can be controlled by limiting sexual contact to one partner, and using a condom during intercourse.

Gonorrhea

Gonorrhea is caused by a bacterium. Symptoms include severe pain on urination (particularly in the male) since the bacterium invades the tissues of the urethra. There is a discharge of pus from the urethra (from the end of the penis in the male). The infection may spread to produce inflammation of the uterus in the female and of the epididymis in the male. The disease is not life-threatening, but it may lead to sterility. Methods of treatment, prevention and control are similar to those described for syphilis.

AIDS

Acquired immune deficiency syndrome (AIDS) is caused by the human immune-deficiency virus (HIV). The virus affects the body's ability to fight infection. It lives in **body fluids** such as **blood** and **semen**.

Transmission

HIV may be transmitted in the following ways:

- (i) From host to host when intravenous drug users **share unsterilised needles**. A small amount of blood may enter the needle and syringe when a person injects a drug. If another person uses the same, unsterilized needle, they will receive the blood of the first user, who may be infected.
- (ii) In **semen**, from one partner to the blood of another, if there is any tearing of tissues during intercourse.
- (iii) From an infected mother's blood to her baby's blood during the **birth** process.
- (iv) In untreated blood during **blood transmission**.

Disease control

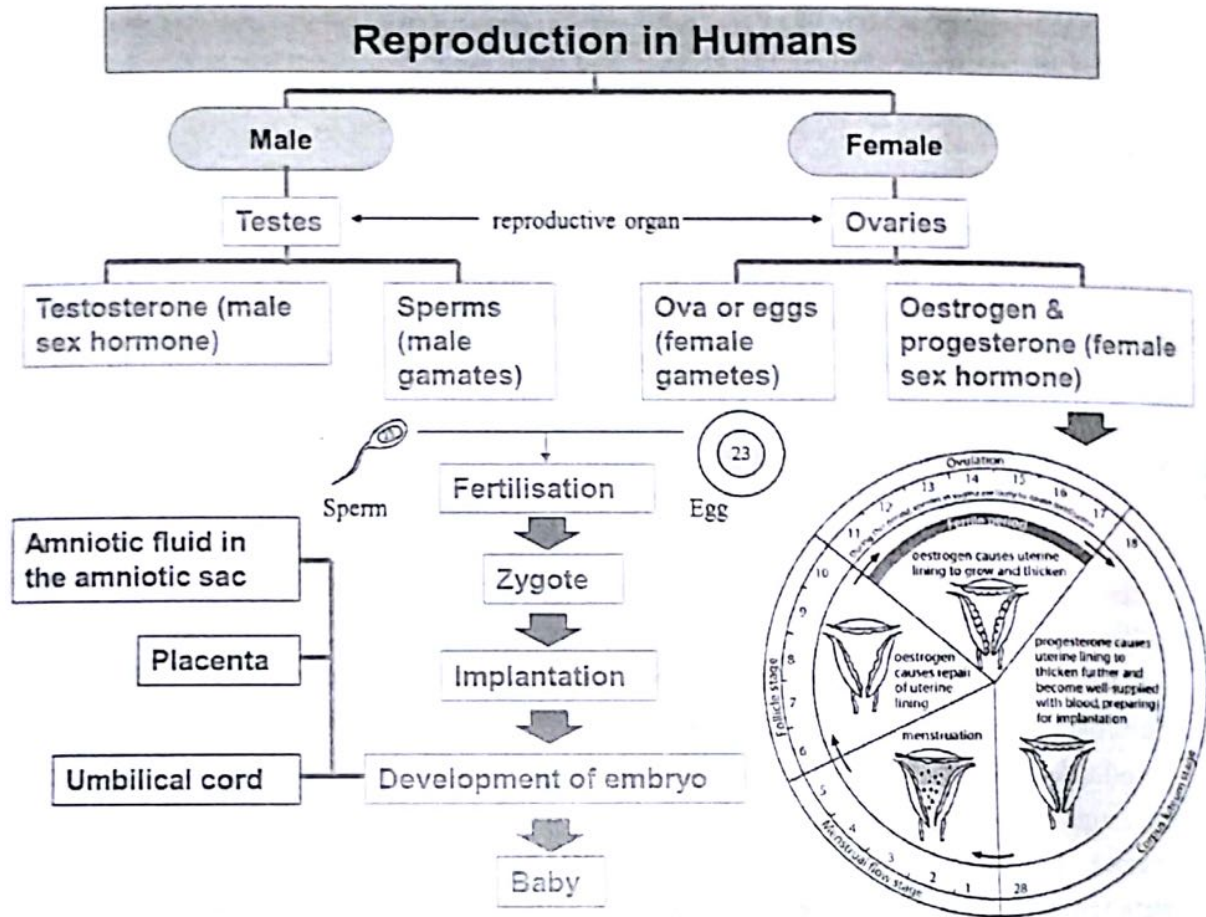
Although the drug AZT can slow the progress of the disease, there is, as yet, no cure for AIDS. It can, however, be controlled by:

- (i) **Educating** the public about how it is spread, and what precautions can be taken.
- (ii) **Never sharing needles**.

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- (iii) **Avoiding sex with prostitutes** because they are often carriers of the disease. Staying with **one STD-free partner**.
- (iv) **Always using a condom** or other barrier method of contraception which prevents direct contact between the body fluids of the two partners.
- (v) **Treating** all blood and blood products used in transfusions to destroy the AIDS virus.

Concept Map



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Syllabus Check List Development of Organisms and Continuity of Life

After reading chapter are you able to:

- ☐ define mitosis as cell division giving rise to genetically identical cells in which the chromosome number is maintained and state the role of mitosis in growth, repair of damaged tissues, replacement of worn out cells and asexual reproduction
- ☐ define asexual reproduction as the process resulting in the production of genetically identical offspring from one parent and describe **one** named, commercially important application of asexual reproduction in plants
- ☐ define meiosis as a reduction division in which the chromosome number is halved from diploid to haploid
- ☐ state that gametes are the result of meiosis (reduction division)
- ☐ define sexual reproduction as the process involving the fusion of haploid nuclei to form a diploid zygote and the production of genetically dissimilar offspring
- ☐ identify and draw, using a hand lens if necessary, the sepals, petals, stamens and carpels of **one**, locally available, **named**, insect-pollinated, dicotyledonous flower, and examine the pollen grains under a light microscope
- ☐ state the functions of the sepals, petals, anthers and carpels
- ☐ use a hand lens to identify and describe the anthers and stigmas of **one**, locally available, **named**, wind-pollinated flower, and examine the pollen grains under a light microscope
- ☐ outline the process of pollination and distinguish between self-pollination and cross-pollination
- ☐ compare, using fresh specimens, an insect-pollinated and a wind-pollinated flower
- ☐ describe the growth of the pollen tube and its entry into the ovule followed by fertilisation (production of endosperm and details of development are not required)
- ☐ investigate and describe the structure of a non-endospermic seed in terms of the embryo (radicle, plumule and cotyledons) and testa, protected by the pericarp (fruit wall)
- ☐ state that seed and fruit dispersal by wind and by animals provides a means of colonising new areas
- ☐ describe the external features of **one**, locally available, **named** example of a wind-dispersed fruit or seed and of **one** named example of an animal-dispersed fruit or seed
- ☐ investigate and state the environmental conditions that affect germination of seeds: suitable temperature, water and oxygen
- ☐ describe the uses of enzymes in the germination of seeds
- ☐ identify on diagrams of the male reproductive system and state the functions of the testes, scrotum, sperm ducts, prostate gland, urethra and penis
- ☐ identify on diagrams of the female reproductive system and state the functions of the ovaries, oviducts, uterus, cervix and vagina
- ☐ compare male and female gametes in terms of size, numbers and mobility
- ☐ describe the menstrual cycle, with reference to the alternation of menstruation and ovulation, the natural variation in its length and the fertile and infertile phases of the cycle
- ☐ explain the role of hormones in controlling the menstrual cycle (including FSH, LH, progesterone and oestrogen)
- ☐ describe fertilisation and early development of the zygote simply in terms of the formation of a ball of cells that becomes implanted in the wall of the uterus

- ☐ state the function of the amniotic sac and the amniotic fluid
- ☐ describe the function of the placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and excretory products (no structural details are required)
- ☐ describe the special dietary needs of pregnant women
- ☐ describe the advantages of breast milk compared with bottle milk
- ☐ describe the following methods of birth control:
natural, chemical (spermicides), mechanical, hormonal and surgical
- ☐ explain that syphilis is caused by a bacterium that is transmitted during sexual intercourse
- ☐ describe the symptoms, signs, effects and treatment of syphilis
- ☐ discuss the spread of human immunodeficiency virus (HIV) and methods by which it may be controlled.

O-LEVEL

BIOLOGY

Topic 17:
Inheritance

NOTES BY

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Cell: 0334-4463339

Syllabus 2017 – 2019

Content

- 17.1 Variation
- 17.2 Chromosomes and DNA
- 17.3 Monohybrid inheritance
- 17.4 Selection
- 17.5 Genetic engineering

INHERITANCE

Variation

Sexual reproduction leads to **variation** in the offspring, that is, each individual has different characteristics. No two offspring from the same parents, produced by sexual reproduction, are genetically identical. An exception occurs when the offspring develop from the same ovum and sperm, in which case they are 'identical twins'. Two types of variation are **continuous** and **discontinuous**.

Continuous variation

Continuous variation is the result of the interaction of **two** factors:

- (i) the genes that are inherited by an individual
- (ii) the effect of the environment on the individual.

The **environmental** factors involved might include:

- the availability and type of food (in animals)
- disease
- the climate (amount of sunlight, temperature, amount of available water)
- the ions present in the soil (in plants)
- competition from other organisms in the environment.

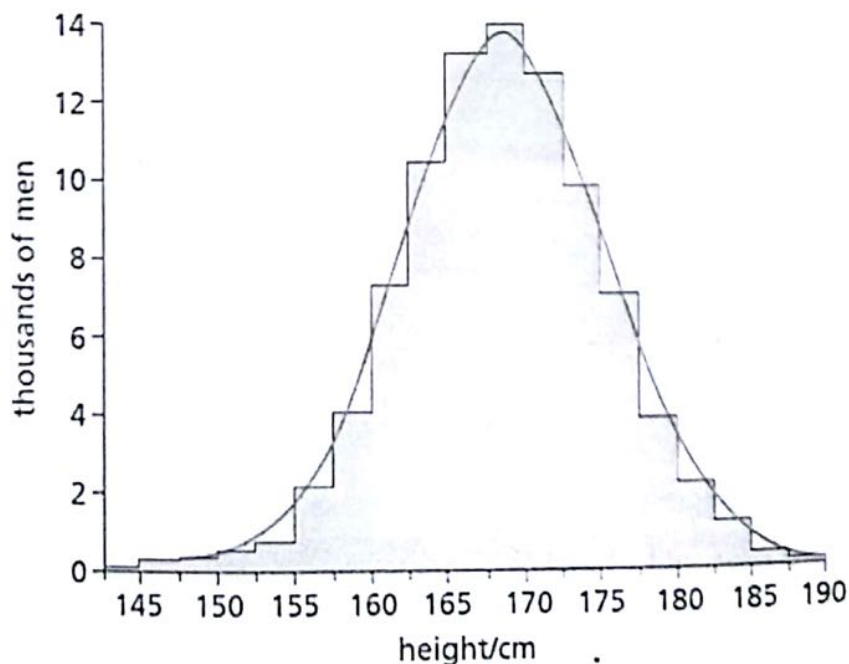
In continuous variation, individuals show a **range** between the two extremes. Every possible form between the two extremes will exist.

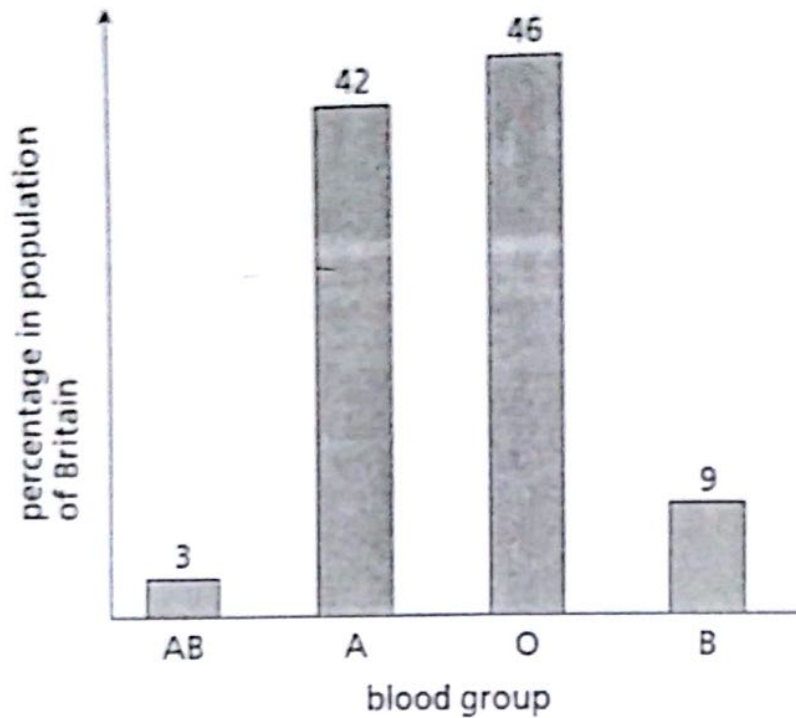
Examples of continuous variation are body mass, height and foot size.

Discontinuous variation

This is the result of **inheritance** only. There are few types, with no intermediates.

Examples of discontinuous variation are blood groups and the ability to roll the tongue into a 'U' shape; either you can or you cannot.



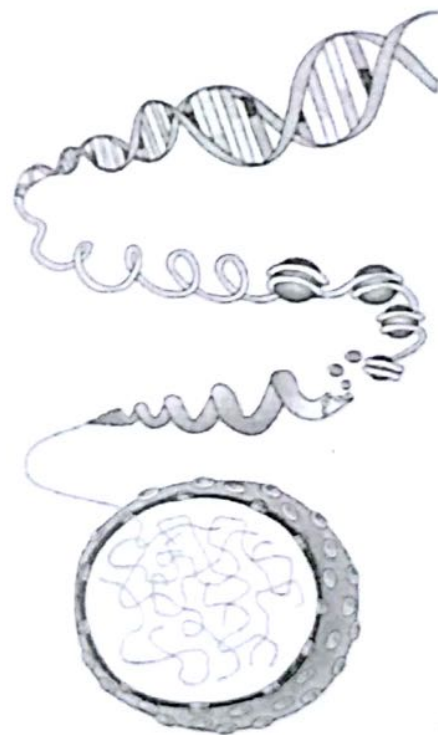


The chemical structure of chromosomes

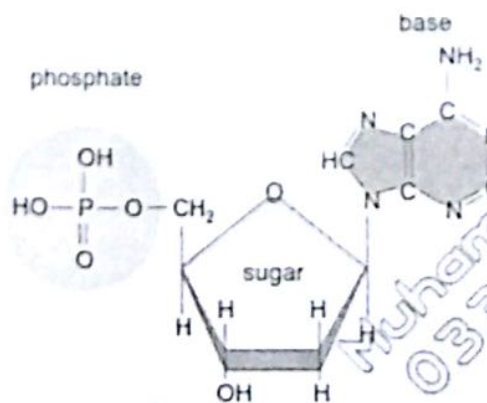
Chromosomes, situated in the **nuclei** of all living cells (except bacteria, which have no true nucleus) are made of the chemical substance **DNA**. DNA is a **polynucleotide chain**. The basic structural and functional unit of DNA is therefore nucleotide. A nucleotide is made up of a **deoxyribose sugar**, a **nitrogenous base** and a **phosphate**.

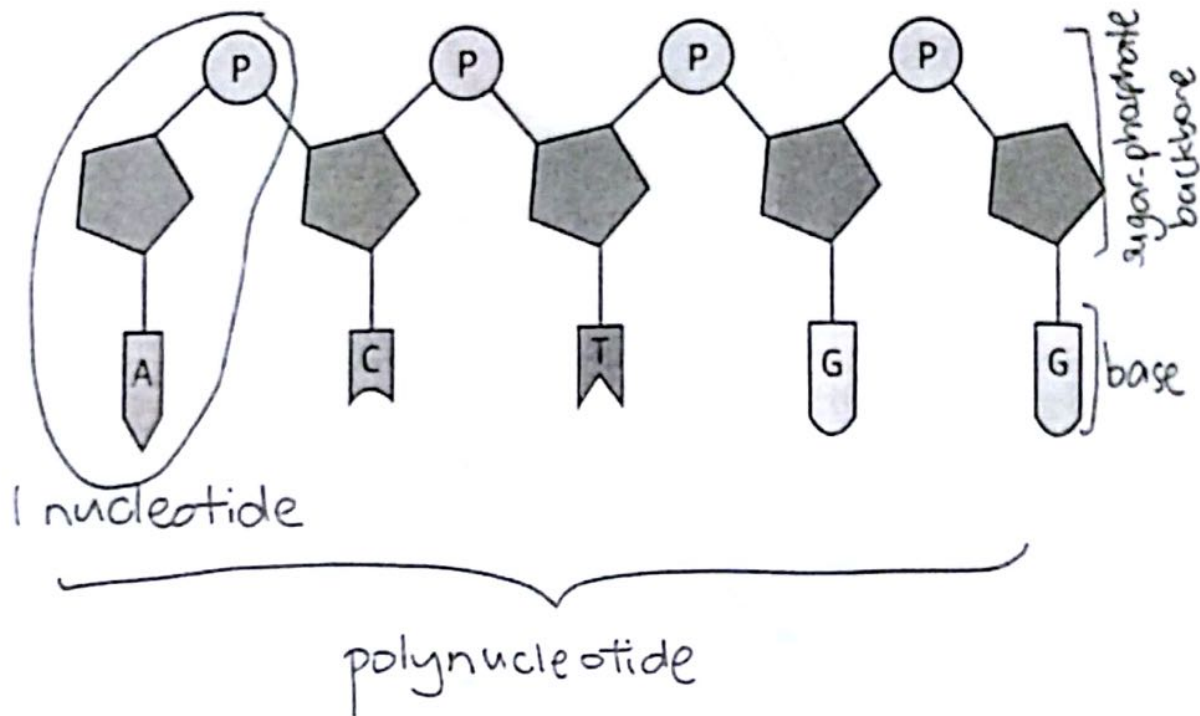
There are **four nitrogenous bases** found in DNA:

1. A - Adenine
2. C - Cytosine
3. G - Guanine
4. T - Thymine



A Nucleotide

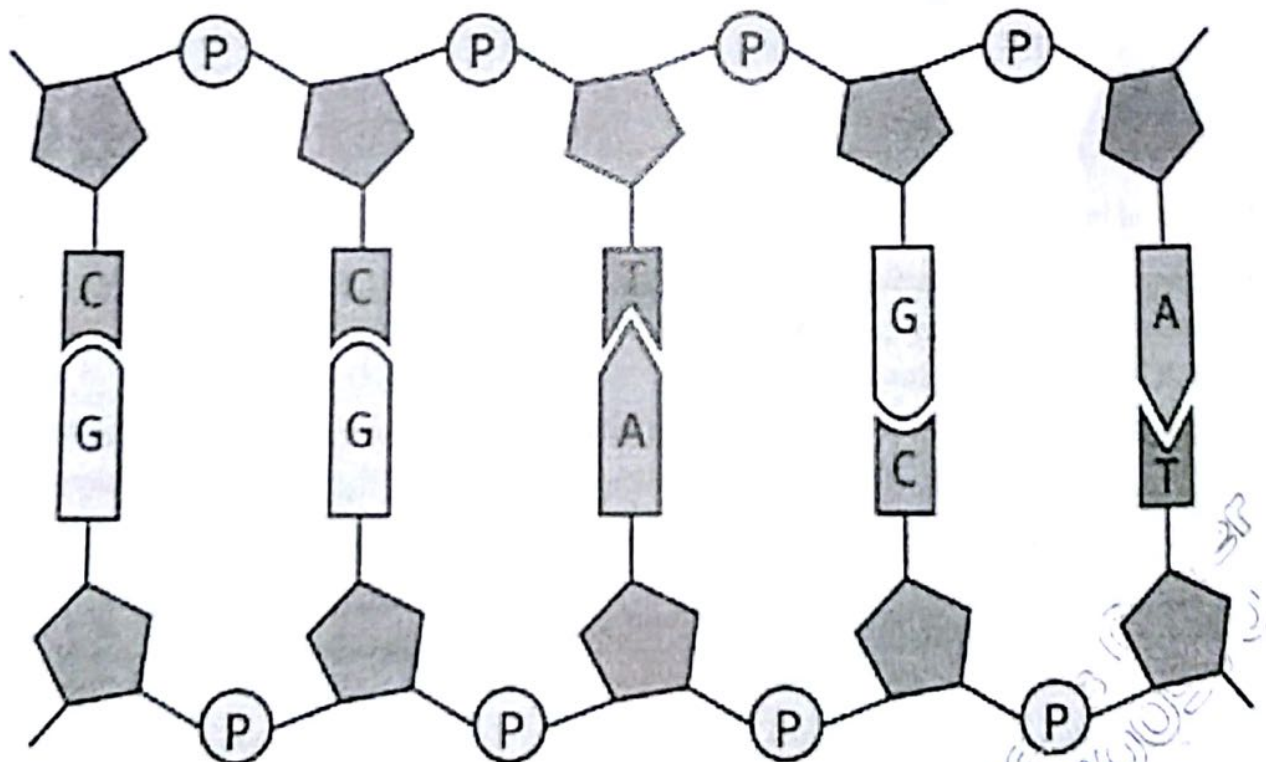




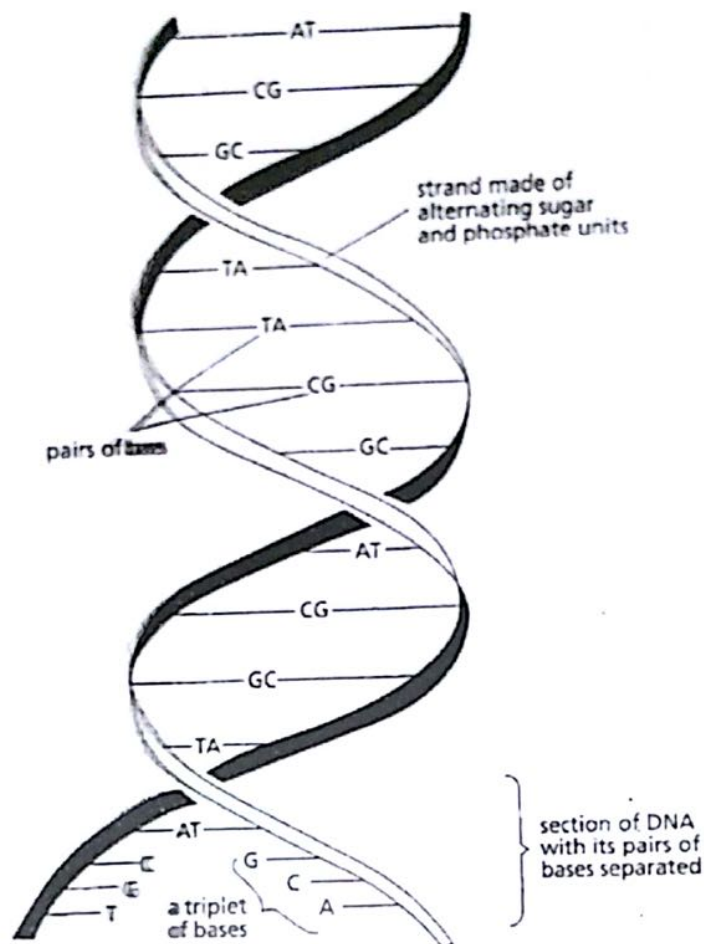
These bases link with one another in the following ways ('the rule of base pairing')

A always with T

C always with G



The DNA molecule, looking rather like a very long, twisted rope ladder, is made up of two strands (of alternating sugar and phosphate units) held together by pairs of chemical units called **bases** (the steps of the ladder). The molecule is described as a **double helix**.

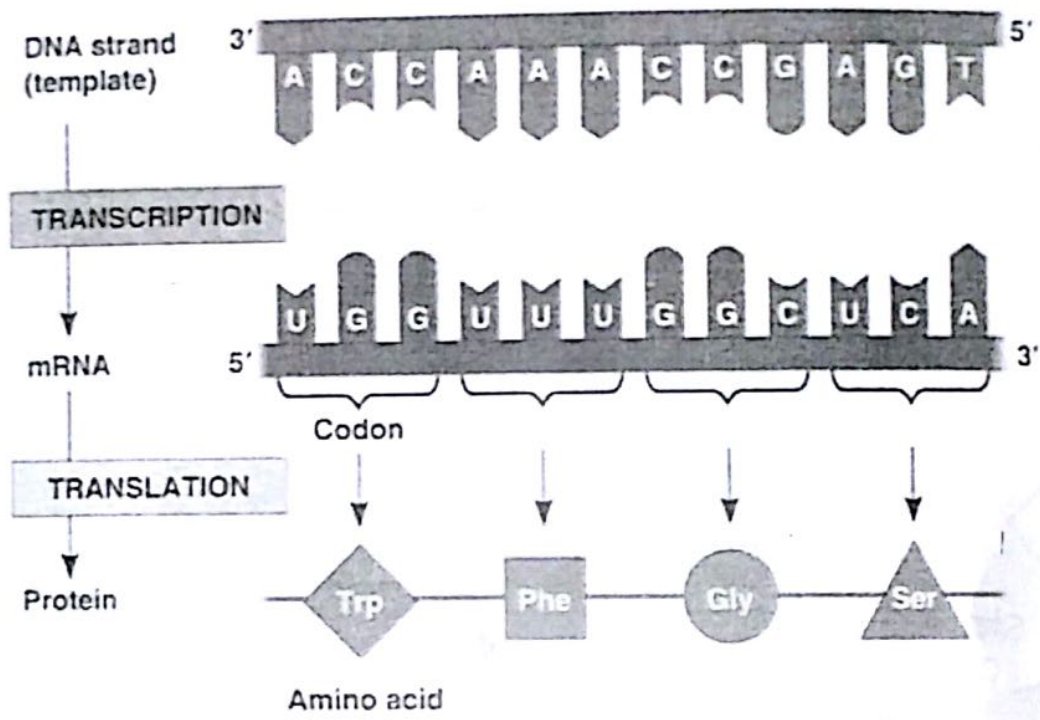
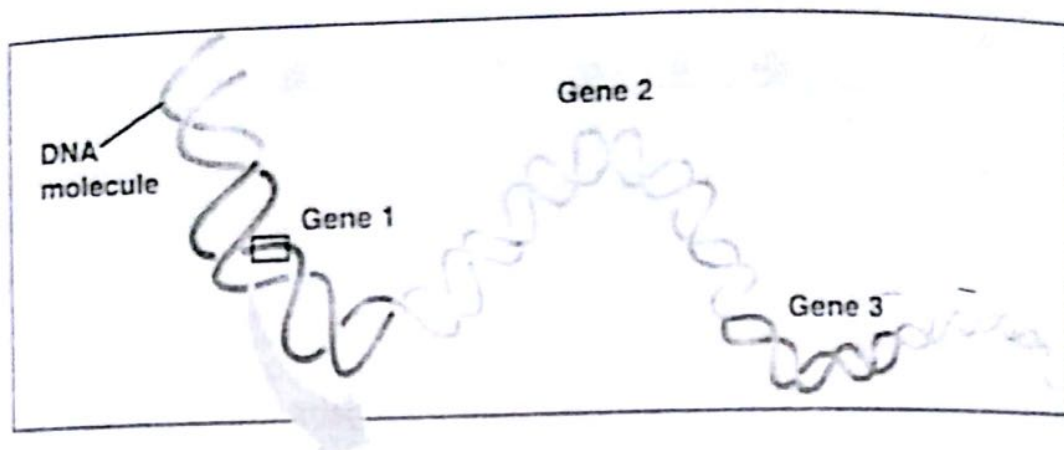


The unit of inheritance

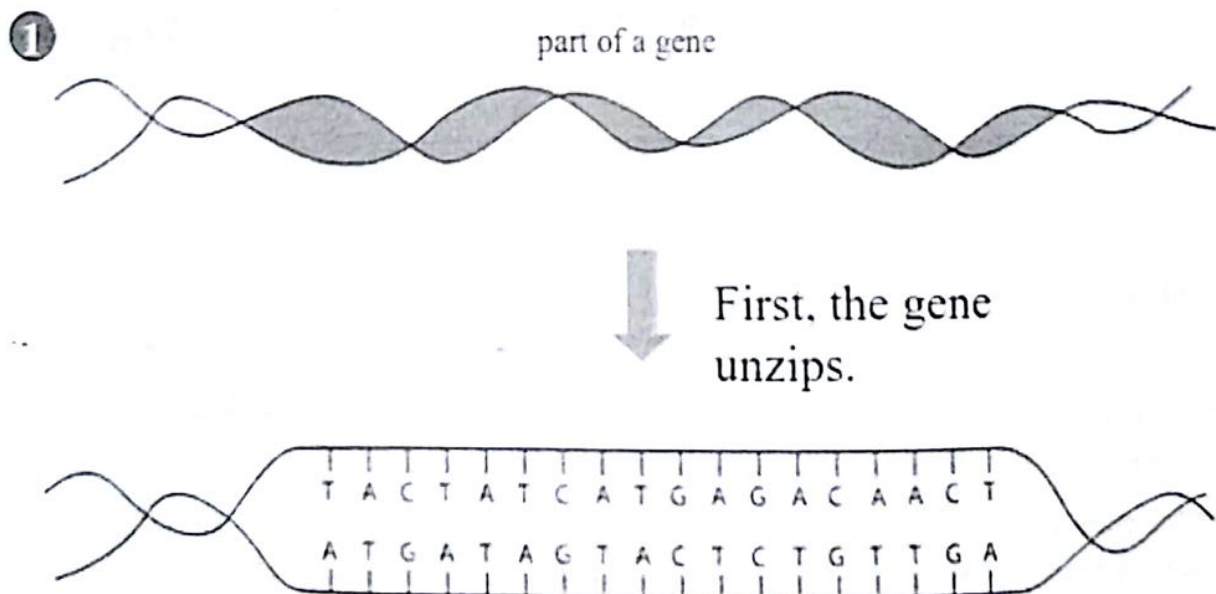
All living organisms manufacture proteins in their cells. These are used either for structural purposes within the cell or as **enzymes** to control chemical processes in the cell. All proteins are made up of linked **amino acids**.

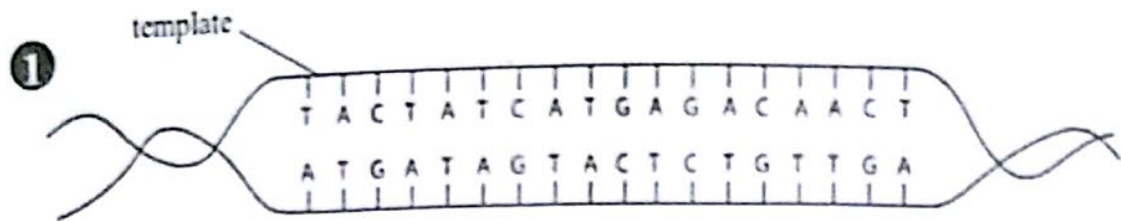
The sequence of bases (e.g. **CATCTAGCCTA**) on one of the two strands is a **code**. When protein molecules are made in the **cytoplasm** of a cell, a copy of the bases on a section of a DNA strand is made and passed **out** into the cytoplasm of the cell. The sequence of bases is first split into **triplets** (CAT, **GCT**AGC, CTA). Each triplet is then responsible for lining up on particular amino acid in the **sequence** of amino acids that will link to form a protein. Each of the 22 amino acids has its own **triplet**.

Since the sequence of bases on **DNA** molecules is different for each (sexually-produced) individual, it follows that no two **individuals** will make protein molecules with exactly the same sequence of amino acids.



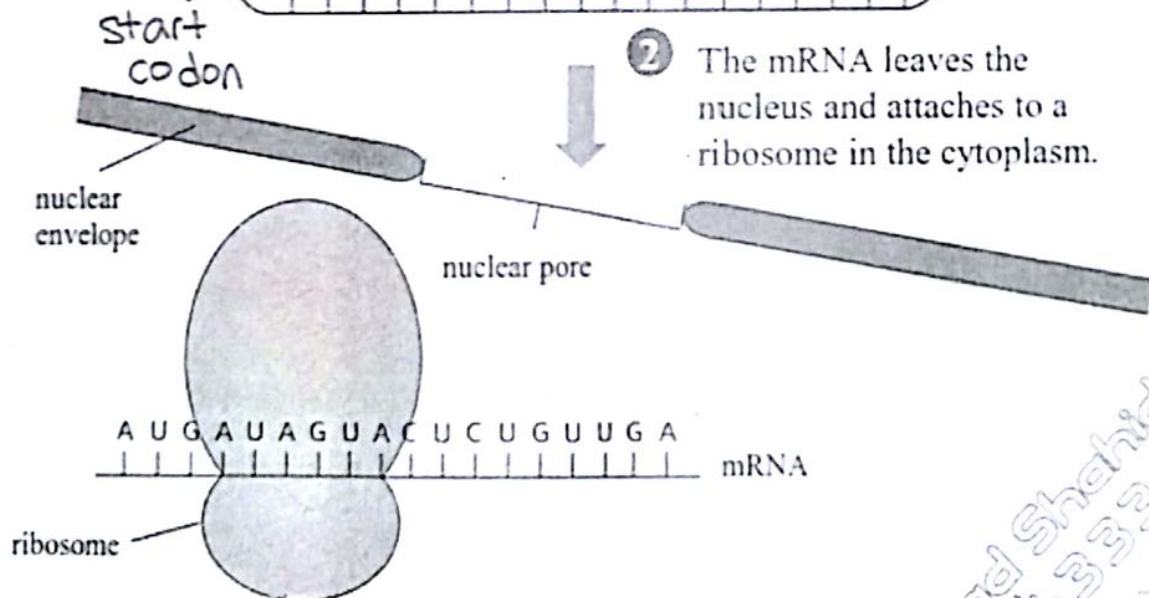
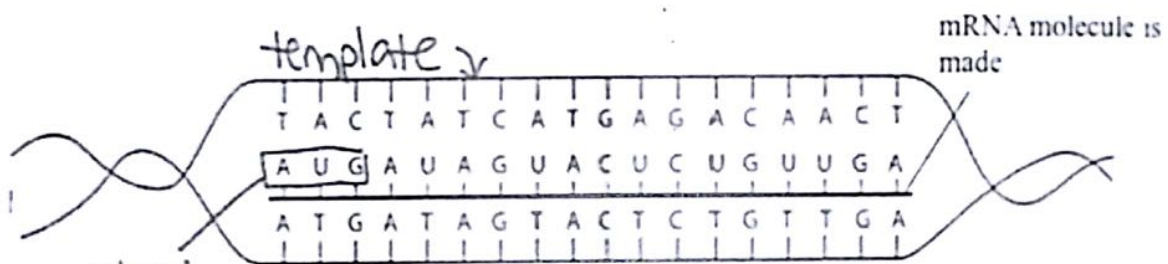
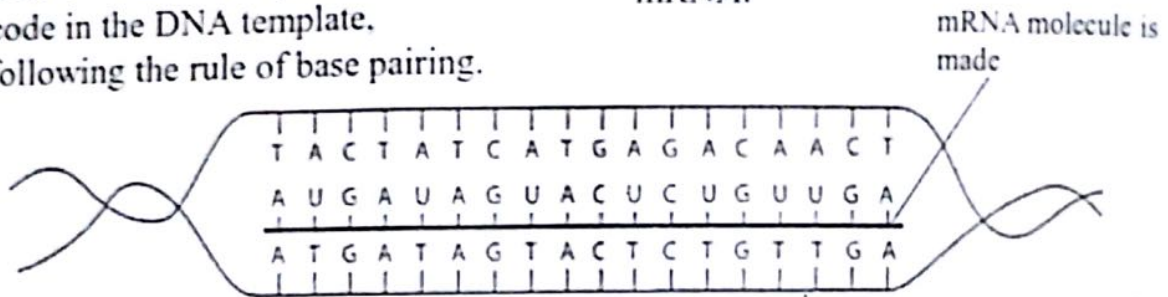
Transcription and Translation





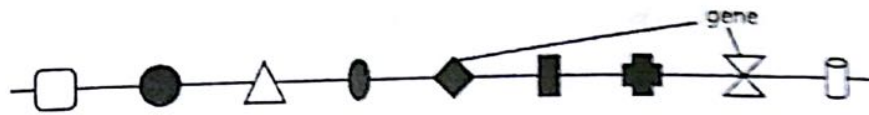
- One of the strands in the gene is used as the template to make mRNA. This is transcription. The mRNA molecule copies the genetic code in the DNA template, following the rule of base pairing.

Note that mRNA does not contain T (thymine). A (adenine) in DNA pairs with U (uracil) in mRNA.



The length of chromosomes which contains the bases necessary to make one protein molecule is otherwise known as a **gene**. A **gene** is defined as a unit of inheritance.

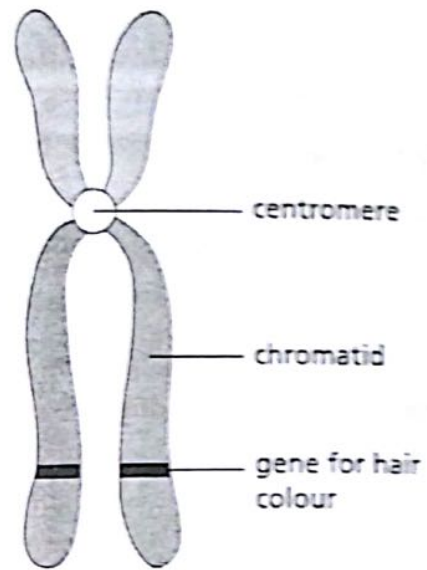
For the purpose of understanding in the mechanism of simple inheritance, it is convenient to imagine a chromosome as a string of beads, like that shown below, each bead represents on gene.



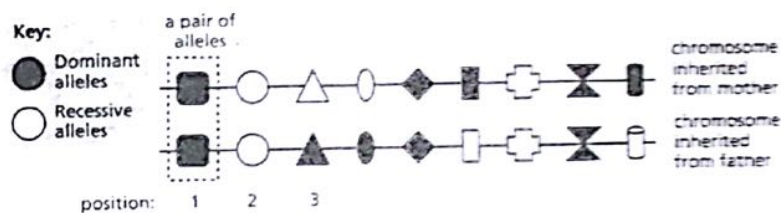
During cell division, genes are copied and these copies are passed on from parent to offspring via chromosomes in the nuclei of the parents' gametes.

Genetic inheritance

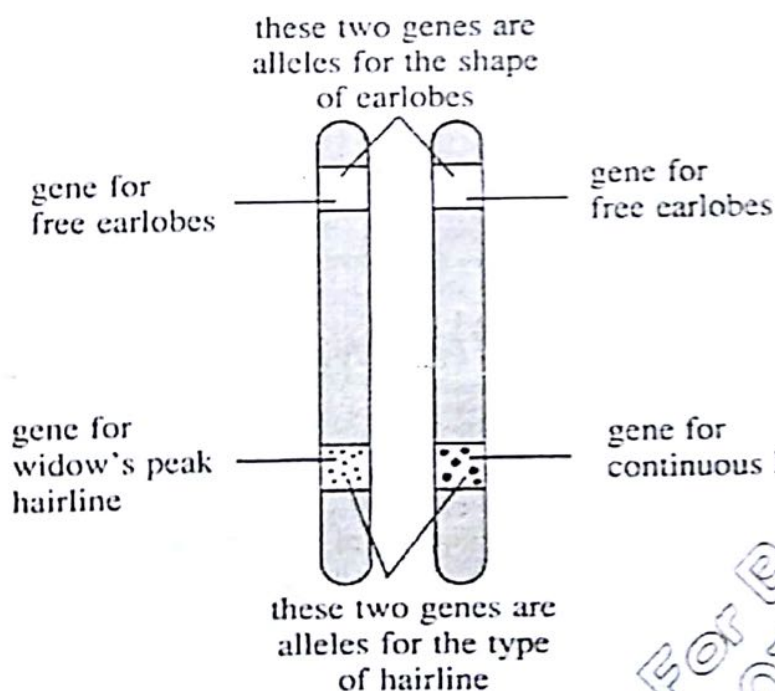
Every member of the same species has the same number of chromosomes in each (healthy) cell of their body. These chromosomes exist in matching pairs. For example, human beings have 23 matching or **homologous** pairs of chromosomes, a total number of 46. Of each pair of matching chromosomes, one is inherited from a person's mother and one is inherited from their father.



The genes of homologous chromosomes also match. In other words, if we look at two strings of beads, the order of the different shapes of beads is the same on both strings. Matching genes on homologous chromosomes are called **alleles**.



A pair of beads (like the two ■ shown at position 1) always match in shape, but do not always match in colour. This is a way of showing that one pair of alleles controls one character, but each allele may exist in two forms: they may be dominant or recessive.



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For a particular character, an offspring may therefore inherit either:

- Two dominant alleles, one from each parent. The offspring is described as **homozygous dominant**.
- Two recessive alleles, one from each parent. The offspring is described as **homozygous recessive**.
- One dominant and one recessive allele. The offspring is described as **heterozygous**.

These are the three possible **genotypes** of the individual.

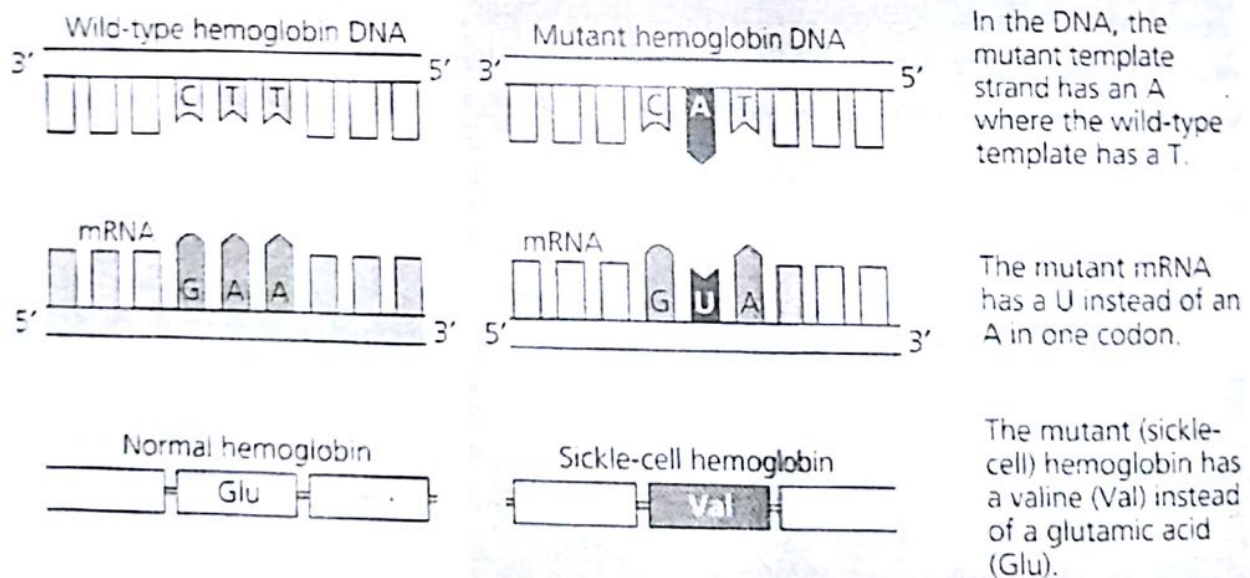
If at least **one** dominant allele is present in the genotype, the individual will show the dominant feature in their appearance or **phenotype**. Thus the homozygous dominant and heterozygous genotypes will give the same phenotype. The homozygous recessive individual will have the alternative or **contrasting** phenotype.

Variation as a result of mutation

A **mutation** is a spontaneous change in the structure of a gene or chromosome. Genes and chromosomes are always subject to change or **mutation** as a result of environmental forces acting upon them. These forces are known as **mutagens**, and include **X-rays**, **atomic radiation**, **ultraviolet light** and some **chemicals**. Exposure to higher doses of any of these mutagens will lead to a greater rate of mutation.

Example of gene mutation

Sickle-cell anaemia is an example of a condition caused by a gene mutation. Both parents pass on a **mutated** and recessive allele for making **haemoglobin** in red blood cells. The homozygous recessive offspring cannot make effective haemoglobin, and cannot carry insufficient oxygen in their blood. Their red blood cells also take on a distorted shape. A person with this condition is likely to die at an early age.



Example of chromosome mutation

Down's syndrome is an example of a condition caused by a chromosome mutation. There are 23 **unpaired** chromosomes in each gamete. Forty-six is known as the **diploid** number, and 23 as the **haploid** number. If, in the production of gametes by one of the parents, one extra

chromosome enters one of the gametes, then there will be **24 instead of 23** chromosomes in that gamete. If this gamete is involved in the process of fertilisation, there will be **47 instead of 46** chromosomes in the zygote. In older parents, there is a greater tendency for **chromosome number 21** not to separate properly as gametes are being made.

A child who inherits the extra chromosome will suffer from **Down's syndrome**. Their physical and mental development will be slow, and they will have a distinctive facial appearance.

Monohybrid inheritance

Organisms inherit alleles for thousands of different contrasting characters, for example, human hair is either curly or straight, and we either can or cannot smell the scent of certain flowers.

Monohybrid inheritance refers to only **one pair** of contrasting characters, such as curly or straight hair, controlled in the individual by **one pair** of alleles.

There are **two types** of monohybrid inheritance; with **complete dominance** and with **codominance**.

1. With complete dominance

There is where the presence of only **one** dominant allele will decide the appearance (or **phenotype**) of the individual. Example, **coat colour in mice**

In mice, brown coat colour is dominant over grey coat colour. In an experiment, a **homozygous dominant** (or 'pure-breeding') **brown** male mouse mated with a **homozygous recessive** (also pure-breeding) **grey** female mouse. All their offspring (that is, the **F₁** or **first filial generation**) were found to be **brown**.

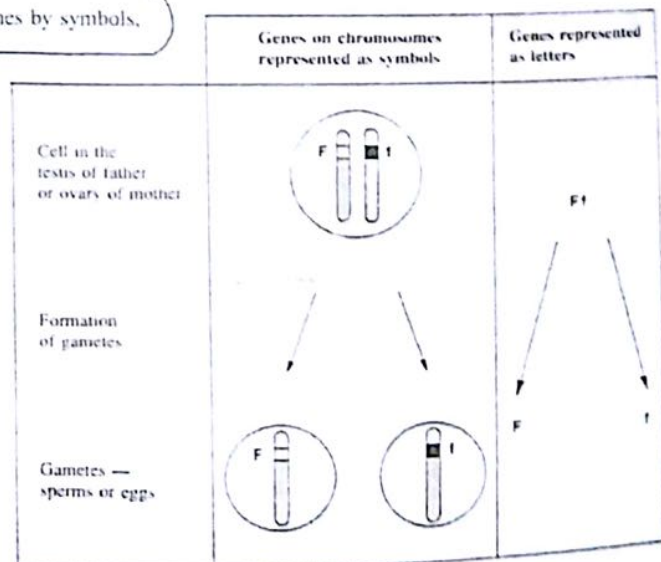
The offspring of the **F₁** generation were then allowed to freely interbreed. It was found that their offspring (the **F₂** generation) were **brown to grey** in a **3:1** ratio. This can be explained in a **genetic diagram**.

Genetic diagrams

Genetic diagrams are a way of looking at the combinations of alleles produced by two parents. In constructing genetic diagrams, the letters of the alphabet (rather than beads) are used to represent alleles. A dominant allele is represented by a **capital** letter (like A, B, C) and its recessive allele is represented by a small (or **lower case**) version of the same letter (like a, b, c). For example:

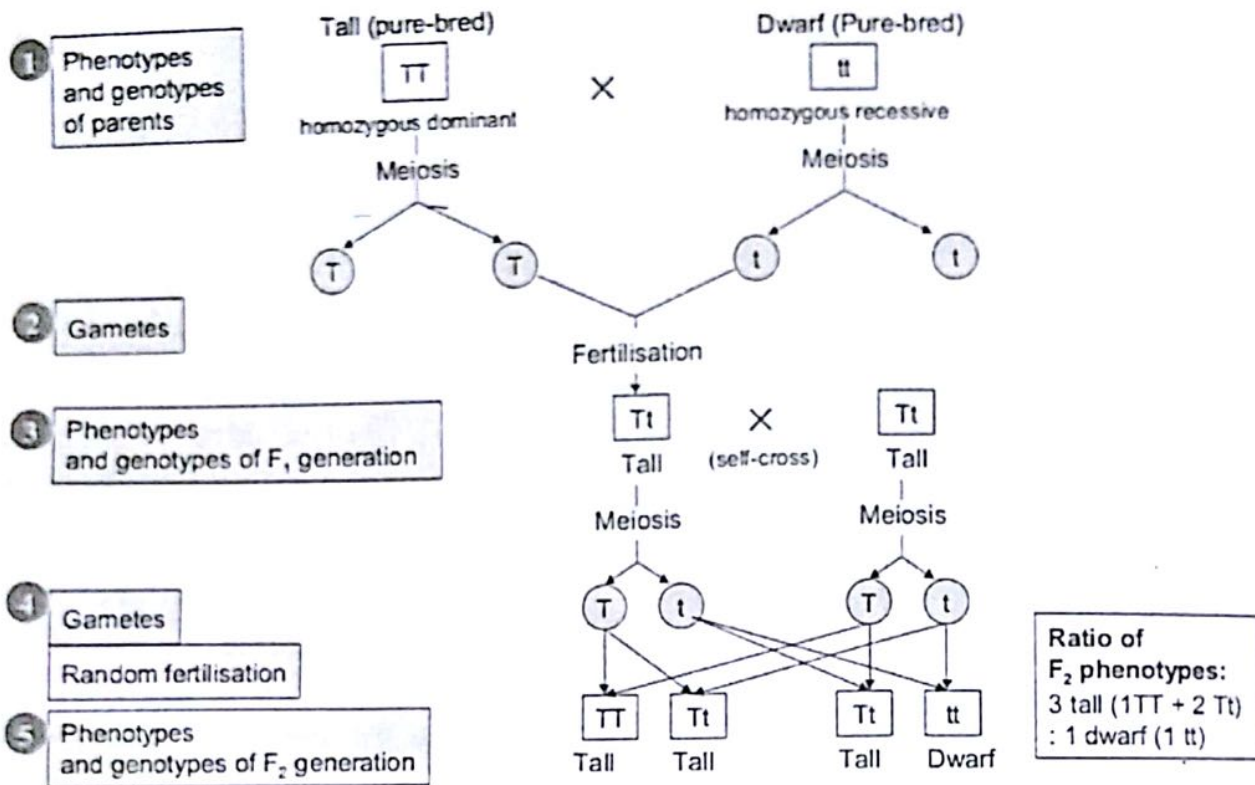
Instead of drawing out chromosomes and representing genes by symbols,

- genes can be represented by letters
- genes that control the same characteristic are given the same letters
- the dominant gene is given a capital letter
- the recessive gene is given a small letter



Alleles separate, one from each pair goes into a gamete

Genetic diagram of a cross between a tall plant and a dwarf plant



Punnett Square of a cross between a tall plant and a dwarf plant

Parents:

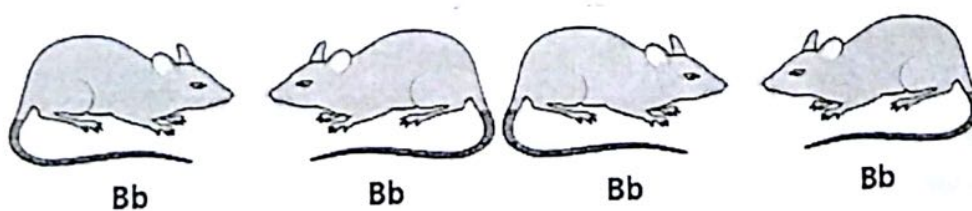
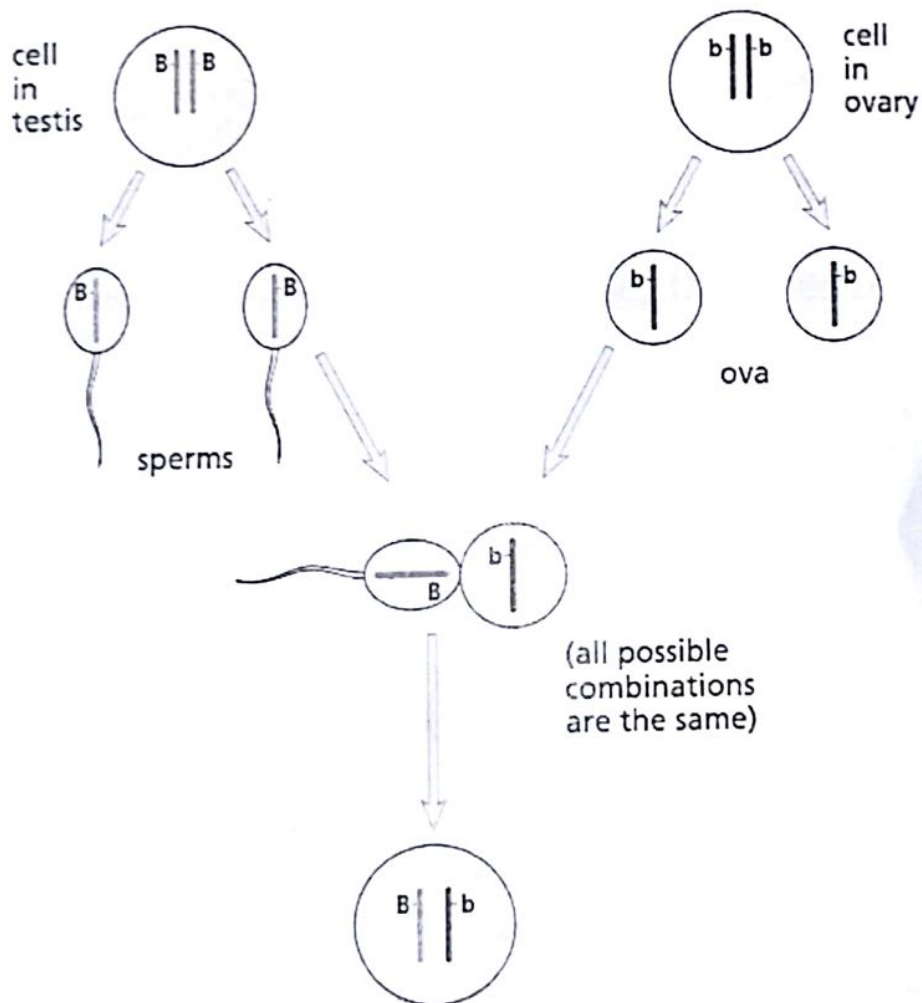
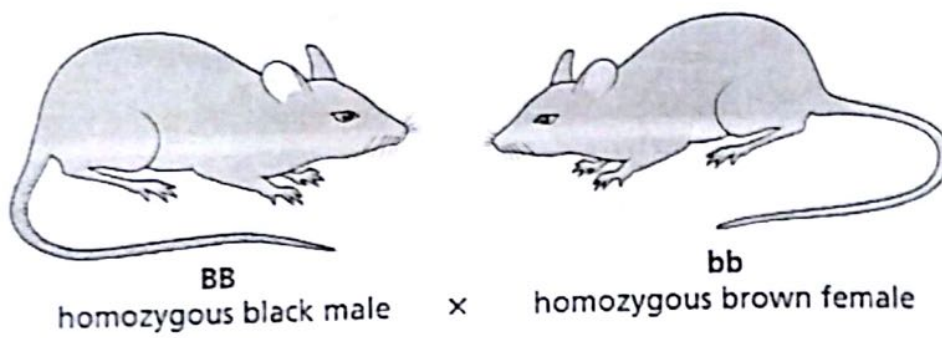
TT	×	tt
Gametes		
	T	T
t	Tt	Tt
t	Tt	Tt

F_1 hybrid self-cross:

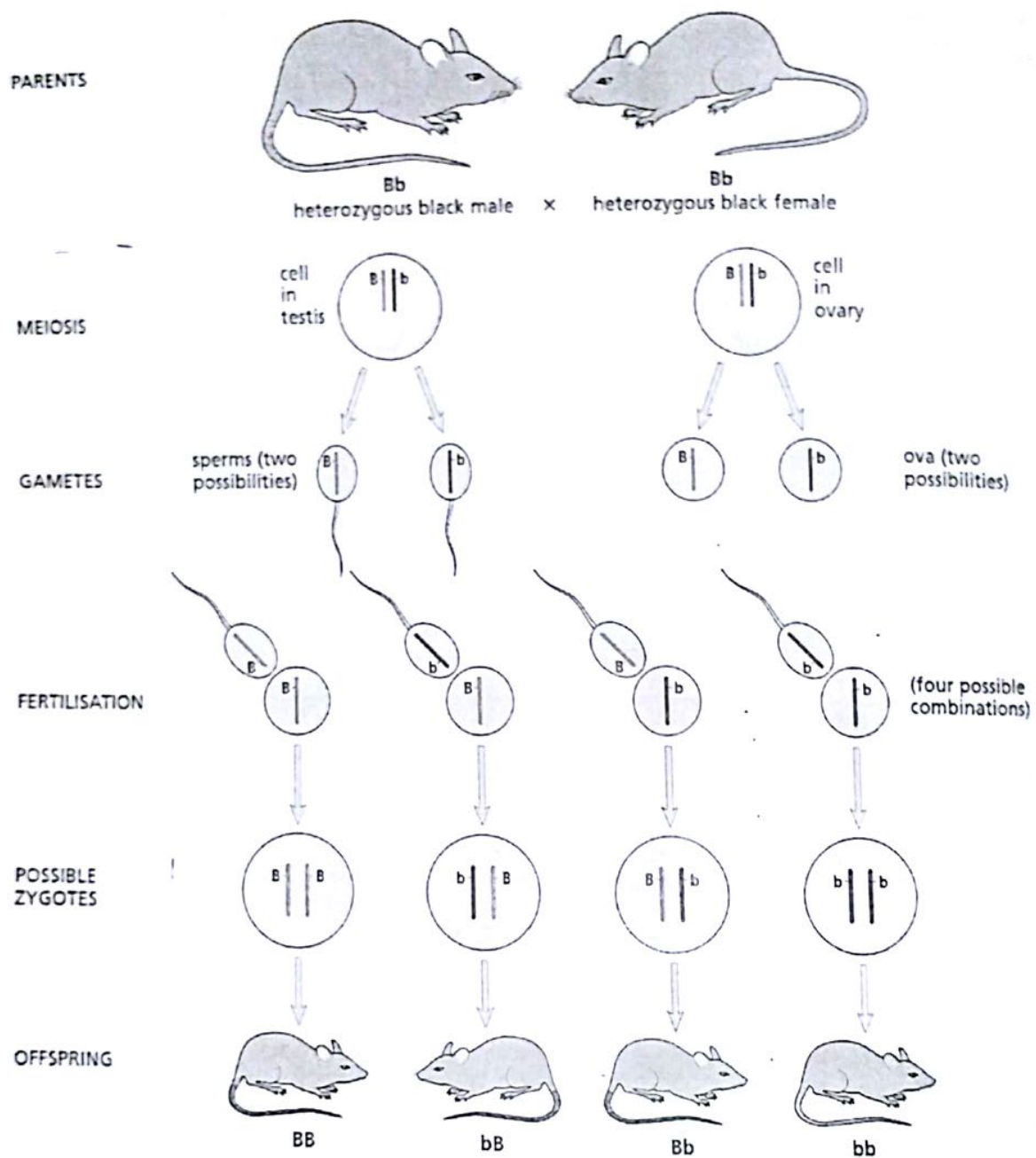
Tt	×	Tt
Gametes		
	T	t
T	TT	Tt
t	Tt	tt

Muhammad Shahid
0334-4463339

Genetic diagram: cross between homozygous brown-coated mouse and homozygous grey-coated mouse



(a) all the F_1 generation are heterozygous black



(b) the probable ratio of coat colours in the F_2 generation is 3 black:1 brown

The results are given as a statistical ratio in a **large** sample. The **smaller** the sample, the **less likely** that the ratios will be the same as shown.

In humans, where only **one** offspring is likely to be produced at a time, the **probability** of that offspring inheriting a particular feature is often given. Probability is usually expressed as a **percentage**.

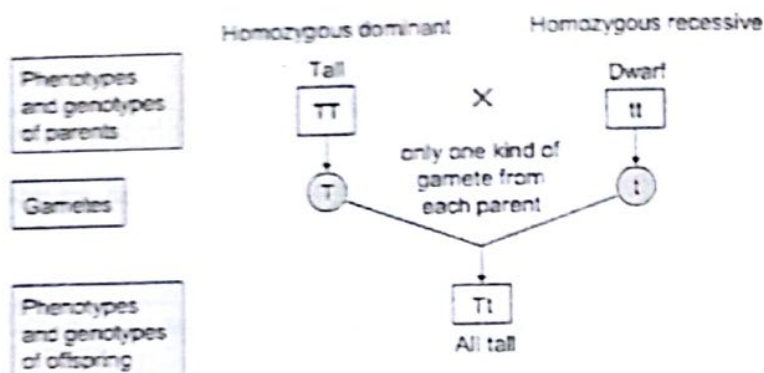
Example of cystic fibrosis in humans

Cystic fibrosis is an inherited condition that affects the type of mucus found in people's lungs. Most people produce normal protein in the mucus of their lungs. They possess at least one dominant allele, which may be called 'F'. The homozygous recessive person, suffering from cystic fibrosis, has the genotype 'ff'. Their lungs contain a particularly thick and sticky mucus, which makes gaseous exchange difficult.

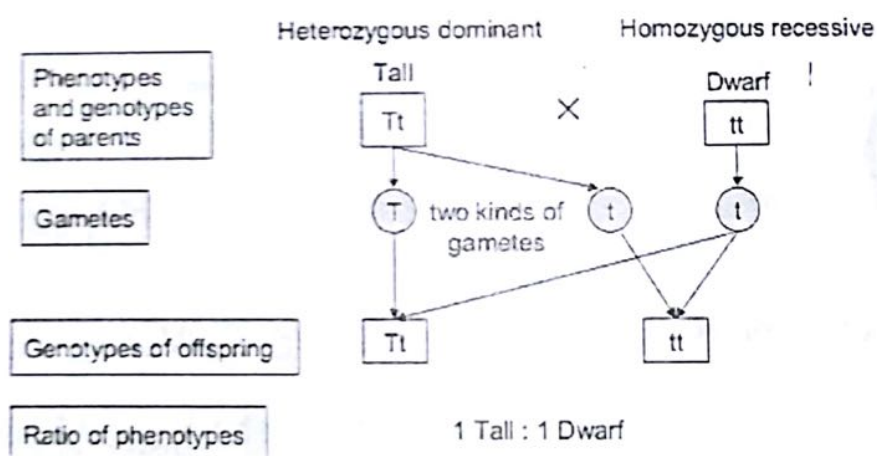
The test (or back) cross

The genotype of an organism showing the dominant trait can be determined by crossing it with an organism that is homozygous recessive. This sort of cross is called a **test cross** or a **back cross**.

- a) If the organism is homozygous dominant, then all the offspring should show the dominant trait.



- b) If the organism is heterozygous, then half the total number of offspring should show the dominant trait. The remaining half should show the recessive trait.



2. With codominance

Sometimes both alleles have an equal effect on the phenotype of an individual. When this happens, the alleles are said to be **codominant**. The individual which is heterozygous will therefore show a **third** phenotype – different from the two homozygous possibilities.

Example of the inheritance of human blood groups

This is also an example of monohybrid inheritance, but this time, there exist **three** possible alleles, only **two** of which are possessed by any one person.

The alleles are described as: I^A , I^B and I^O .

Both I^A and I^B are **dominant** over I^O , but are **codominant** to one another. The following combinations of alleles are possible, resulting in the blood groups (phenotypes) shown:

Genotype	Phenotype
$I^A I^A$	blood group A
$I^A I^O$	blood group A
$I^B I^B$	blood group B
$I^B I^O$	blood group B
$I^O I^O$	blood group O
$I^A I^B$	blood group AB

An example of the inheritance of blood groups in humans can be shown in the following genetic diagram:

Phenotypes of parents blood group A blood group B

Genotypes of parents $I^A I^O$ $\times$ $I^B I^O$

Gametes

(I^A) (I^O) $\times$ (I^B) (I^O)

Punnett square

		$I^A I^O$	
		(I^A)	(I^O)
$I^B I^O$	(I^B)	$I^A I^B$	$I^B I^O$
	(I^O)	$I^A I^O$	$I^O I^O$

F_1 genotypes

$I^A I^O$ $I^B I^O$ $I^A I^B$ $I^O I^O$

F_1 phenotypes

A B AB O

Ratio

1 : 1 : 1 : 1

Key terms

Variation		The different characteristics produced in an individual by sexual reproduction.
	Continuous variation	When both inherited and environmental factors determine the characteristics of an individual (e.g. body mass, height).
	Discontinuous variation	Where inheritance alone determines the characteristics of an individual (e.g. blood group).
Gene		A unit of inheritance, forming part of a chromosome. Passed on from parent to offspring via chromosomes in the nuclei of the parents' gametes.
Gametes		Male or female sex cells.
Alleles		A pair of matching genes.
	Dominant alleles	The presence of a single dominant allele will have the same effect on the phenotype of an individual as the presence of an identical pair of them.
	Recessive alleles	Characters determined by these genes will not appear in an individual unless two recessive (no dominant) alleles are present.
Genotype		The genetic combination of an individual.
	Homozygous dominant	Offspring with two dominant alleles, one from each parent, for a particular character.
	Homozygous recessive	Offspring with two recessive alleles, one from each parent, for a particular character.
	Heterozygous	Offspring with one dominant and one recessive allele for a particular character.
Phenotype		An inherited feature in an individual's appearance. The homozygous dominant and heterozygous genotypes give the same phenotype. The homozygous recessive individual will have a contrasting phenotype.
Mutation		Change in genes or chromosomes through environmental forces, or mutagens (e.g. X-rays, atomic radiation).
Monohybrid inheritance		Inheritance involving only one pair of contrasting alleles.
	Complete dominance	When the presence of a single allele will have the same effect on the phenotype of an individual as the presence of an identical pair of alleles.
	Codominance	When both alleles have an equal effect on the phenotype of the offspring.

The inheritance of sex

Whether a child is born male or female is determined at the moment of fertilisation. Of the 23 pairs of chromosomes in a human nucleus, one pair is known as the **sex chromosome**. In the female, the sex chromosomes are **identical** and are called '**X**' chromosomes. In the male, they are **not identical**. One of them is an '**X**' chromosome, exactly like those in the female, but the other is a (shorter) '**Y**' chromosome.

The sex chromosomes are **XX for a female** and **XY for a male**

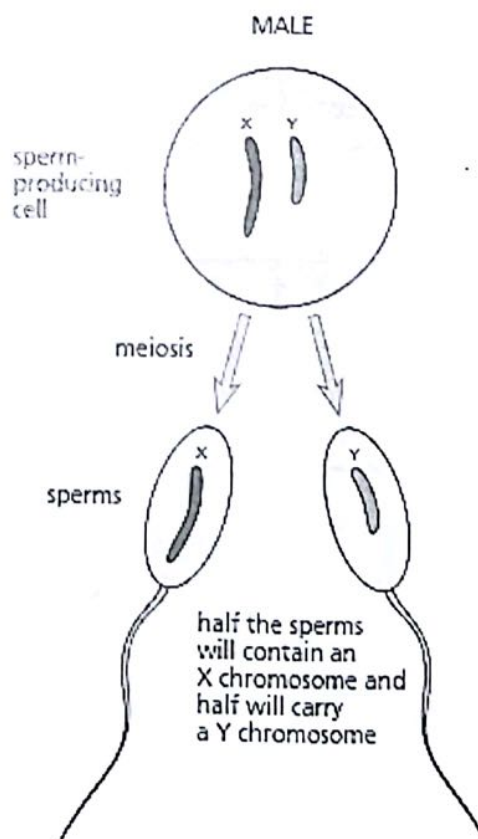
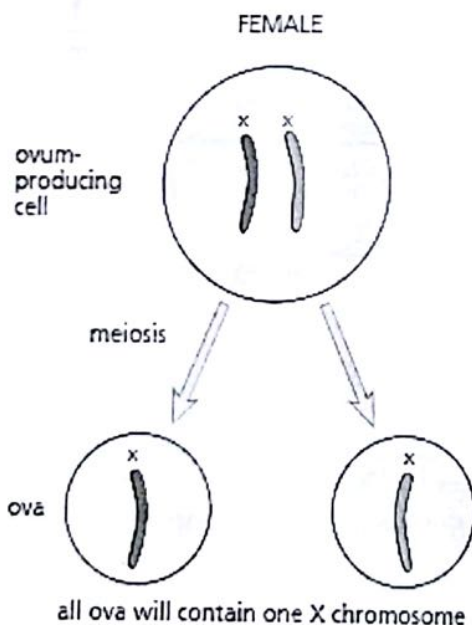
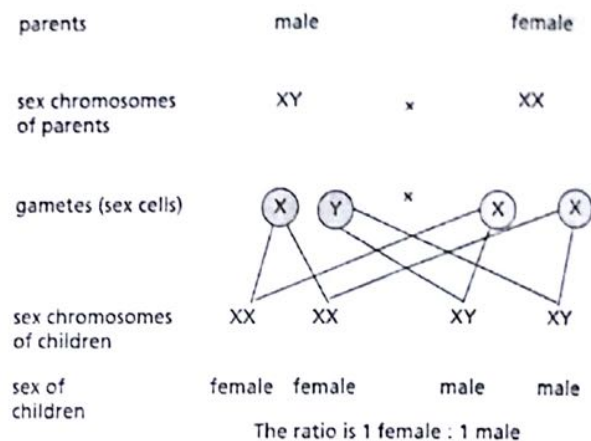
The **gametes** contain 23 **single** chromosomes, and therefore **only one** of the two sex chromosomes that exist in normal body cells.

In **females**, **all gametes** contain an '**X**' chromosomes.

In **males**, 50% of the gametes contain an '**X**' chromosomes and 50% contain a '**Y**' chromosome.

There is an exactly equal chance of the '**X**' chromosomes in the ovum:

- fusing with an '**X**'-carrying sperm to produce a daughter, or
- fusing with a '**Y**'-carrying sperm to produce a son.



Determination of sex. Note that:

- only the X and Y chromosomes are shown
- details of meiosis have been omitted
- in fact, four gametes are produced in each case, but two are sufficient to show the distribution of X and Y chromosomes

Selection

Examples of the variation shown by members of a population in a given habitat include, the shade of colour of a leaf-eating insect, the sharpness of vision in a bird of prey and the speed at which a gazelle can run.

In all of these examples, the variation can have some effect on the success or even on the chances of survival of that organism in its environment:

- (i) The leaf insect with better camouflage may escape the notice of a hungry predator.
- (ii) The bird of prey with sharper vision is more likely to find a meal – particularly important when food is scarce.
- (iii) The faster the gazelle can run, the more chance it has of escaping from a hungry lion.

All organisms are therefore in **competition** with other members of their species in that particularly environment. The winners in that competition **survive** to **reproduce**. The losers provide food for predators, or fail to obtain enough food to remain alive.

It is the environment which 'decides' which organism survive. The process is called **natural selection**.

Variation is controlled by the genes possessed by the organisms. Surviving individuals are able to hand on their advantages, via their genes, to the next generation.

Evolution

The offspring of the survivors also show variation, so the process is repeated over **many generations**. For example, through natural selection, lions may improve their stealth and camouflage over several generations. As they do so, more species become threatened by the lion. Thus, ecosystems are constantly changing and organisms may have to adapt to climate change as well.

This gradual change by natural selection is known as **evolution**. During the process, a population of organisms may become separated and form two isolated branches. Each of the populations will adapt to different environmental change, and **new species** may evolve.

Artificial selection

In the process of **artificial selection**, humans not the environment perform the selecting. That is, people deliberately choose to breed organisms with particular characteristics.

Many crop plants and farm animals are the result of **selective breeding** programs. Some examples are:

- increased milk production in cows
- increased meat production in farm animals
- increased yield from cereals
- increased disease resistance in many crops.

As a result, greater profits are made from greater quantities of better quality produce.

Selective breeding follows this procedure:

1. The individuals showing the quality required are selected.
2. Those individuals are used as breeding stock.
3. Only those offspring showing the desired quality to the greatest extent are selected.
4. These selected individuals are used for breeding.
5. This process is continued over many generations.

There is a danger, however, that this form of 'inbreeding' will increase the chances of two recessive alleles coming together. This may give rise to a genetically-controlled deformity (e.g. a heart defect).

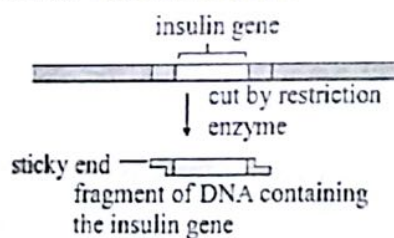
Genetic Engineering

Since we are now able to identify specific genes (i.e. lengths of DNA which encode for the production of a particular protein), that gene can then be isolated and inserted into another organism.

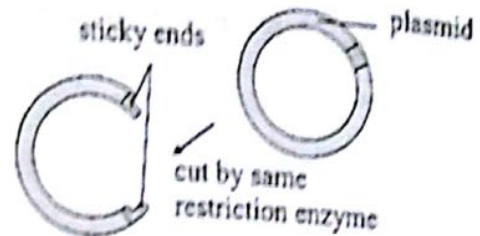
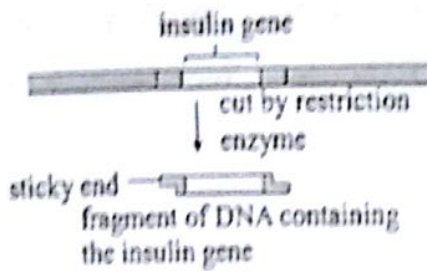
In this way, genes for disease resistance existing in a crop plant with low yield can be introduced into a crop plant with a high yield but low disease resistance. Where a person inherits a genetically-controlled condition (e.g. cystic fibrosis), it may be possible to improve their condition by the introduction of genes from a healthy person. In both these examples, gene transfer is between organisms of the same species.

Gene transfer between organisms of **different** species is commonly used in the production of the hormone **insulin**. In this example, a bacterium is used as the 'host' organism. The gene for insulin production is taken from a healthy person and (using enzymes) attached to the bacterium's chromosome. Every time the bacterium divides, it makes a further copy of the inserted gene. A culture of the bacteria will then not only be manufacturing all the proteins it needs for its own survival, it will also produce an ample supply of insulin molecules. Insulin is now commercially produced using such a process.

How insulin gene is inserted into bacterial DNA

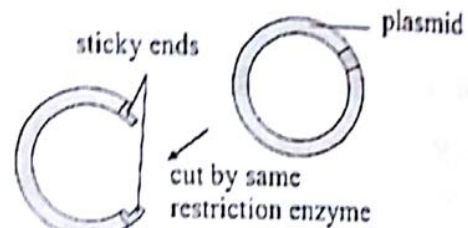
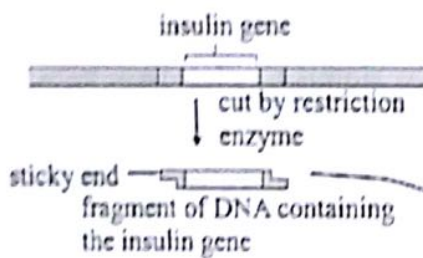


- ① • Obtain the human chromosome containing the insulin gene.
 - Cut the gene using a **restriction enzyme**. This enzyme cuts the two ends of the gene to produce 'sticky ends'.
 - Each 'sticky end' is a single strand sequence of DNA bases. These bases can pair with complementary bases to form a double strand.



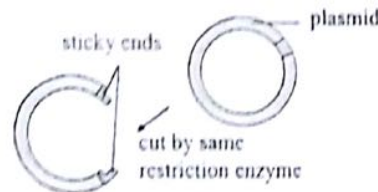
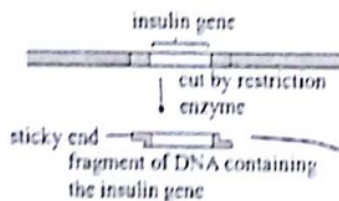
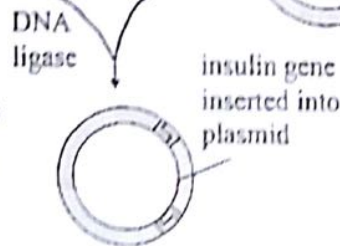
② • Obtain a plasmid from a bacterium.

- Cut the plasmid with the same restriction enzyme. This produces complementary sticky ends.



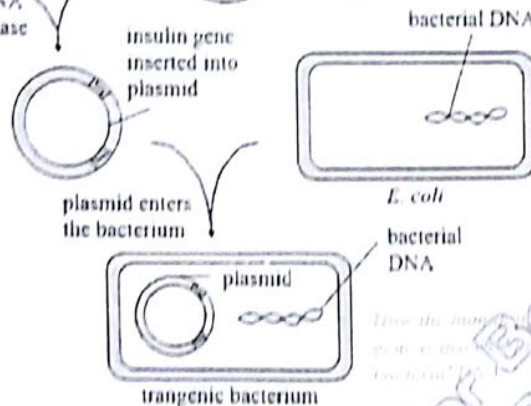
③ • Mix the plasmid with the DNA fragment containing the insulin gene.

- Add the enzyme DNA ligase to join the insulin gene to the plasmid.



④ • Mix the plasmid with *E. coli* bacteria.

- Apply temporary heat or electric shock. This opens up pores in the cell surface membrane of each bacterium for the plasmid to enter.

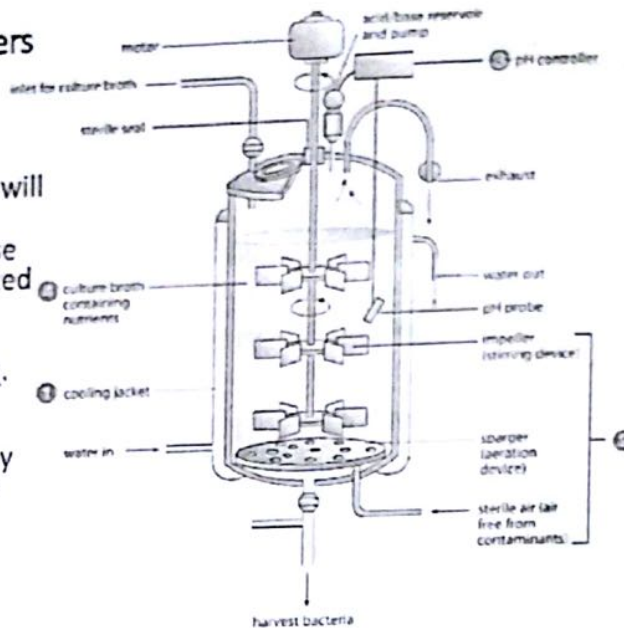


The organism that receives a new gene is known as a transgenic organism.

Large-scale fermenters

- As the transgenic bacteria multiplies, it will use the new gene to produce insulin. These bacteria can be isolated and grown in fermenters for mass production of insulin.

*Insulin production by transgenic bacteria is not a fermentation process!



Public concern over genetic engineering

Genetic engineering can increase food production and help to control disease, but there is much concern over the possibility that bacteria with 'introduced' genes may be accidentally released. Those which make a plant resistant to disease or to pesticides may find their way into pests. There is worry over the safety of foods which have been genetically engineered to improve their flavor and texture. 'Watchdog' committees have been set up to monitor gene transfer experiments.

Muhammad Shahid
0334-4463339

Syllabus Check List Inheritance

After reading chapters are you able to:

- ☐ describe the difference between continuous and discontinuous variation and give examples of each
- ☐ state that a chromosome includes a long molecule of DNA
- ☐ state that DNA is divided up into sections called genes
- ☐ explain that genes may be copied and passed on to the next generation
- ☐ define a gene as a unit of inheritance and distinguish clearly between the terms gene and allele
- ☐ describe complete dominance using the terms dominant, recessive, phenotype and genotype
- ☐ describe mutation as a change in the structure of a gene (e.g. sickle cell anaemia) or in the chromosome number (e.g. 47 in Down's syndrome instead of 46)
- ☐ name radiation and chemicals as factors that may increase the rate of mutation
- ☐ predict the results of simple crosses with expected ratios of 3:1 and 1:1, using the terms homozygous, heterozygous, F_1 generation and F_2 generation
- ☐ explain why observed ratios often differ from expected ratios, especially when there are small numbers of progeny
- ☐ explain codominance by reference to the inheritance of the ABO blood group (phenotypes A, B, AB, O, gene alleles I^A , I^B and I^O)
- ☐ describe the determination of sex in humans (XX and XY chromosomes)
- ☐ describe variation and state that competition leads to differential survival of organisms, and reproduction by those organisms best fitted to the environment
- ☐ assess the importance of natural selection as a possible mechanism for evolution
- ☐ describe the role of artificial selection in the production of economically important plants and animals
- ☐ explain that DNA controls the production of proteins
- ☐ state that each gene controls the production of one protein
- ☐ explain that genes may be transferred between cells (reference should be made to transfer between organisms of the same or different species)
- ☐ explain that the gene that controls the production of human insulin can be inserted into bacterial DNA
- ☐ understand that such genetically engineered bacteria can be used to produce human insulin on a commercial scale
- ☐ discuss potential advantages and dangers of genetic engineering.

Drawing and Labelling

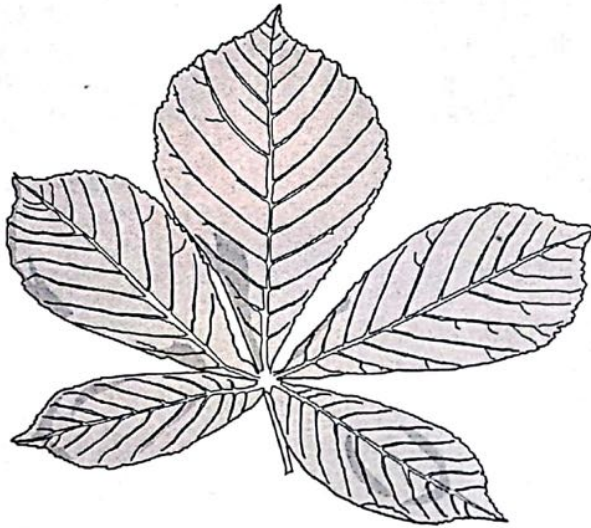
Parameters of making a larger drawing and labelling it

In ATP paper it's almost every paper which checks the drawing skills. Here are some points to consider while drawing:

- Draw using a sharp pencil (HIB) NOT with the pen/pointer or ball point.
- Draw clear, unbroken lines (continuous) without 'tails' or 'overlaps'.
- Do not shade the diagram or any section of drawing unless stated otherwise.
- Draw to scale unless stated otherwise.
- Make large enough drawing which normally occupy more than half the available space.
- If instructed for a larger drawing its better to make it 1.5/2 times larger drawing and that will be helpful later for calculating magnification.
- Use a good eraser to rub out if you make a mistake and then redraw clearly.
- Major structures or features should be clearly labelled using a ruler.
- Keep appropriate proportions of all structures and details.
- Put labels if instructed and justify them according to the marks.
- Keep the same angle of writing while putting the labels (with CAPITAL letters) on drawing.
- Keep the same angle of your drawing as shown in original/given drawing.
- Do NOT draw over the print of question.
- In some cases the examiner wish students to draw some part of the diagram instead of drawing it completely

Worked Solution

- 1 Fig. 2.1 shows leaves from four different trees: horse chestnut, laurel, hornbeam and oak.



horse chestnut



laurel



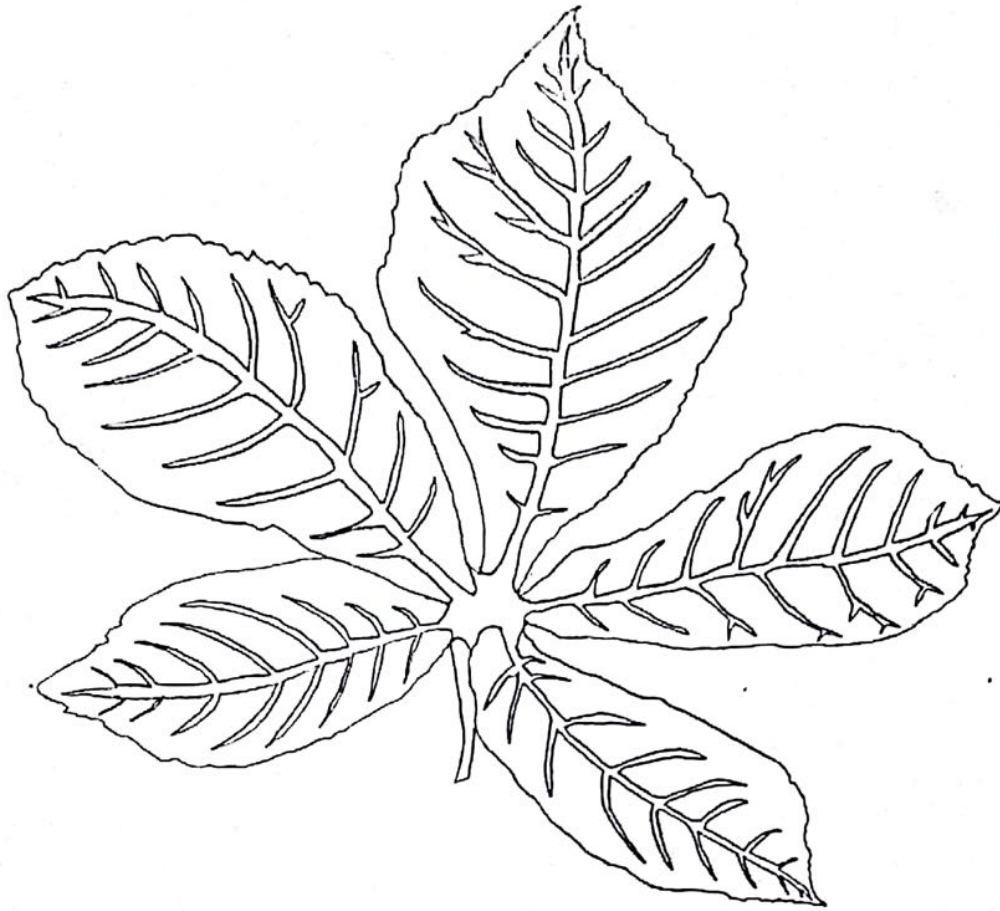
hornbeam



oak

Fig. 2.1

In the space below, make a large drawing of the horse chestnut leaf.
You do not need to label your drawing.



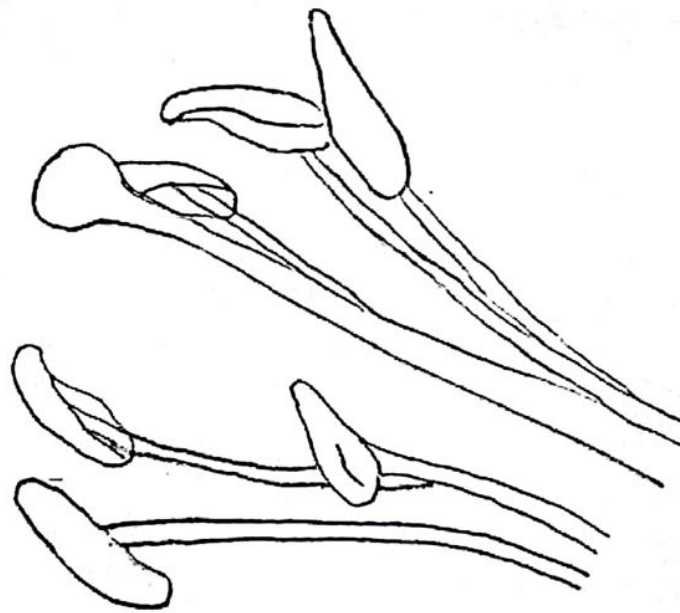
[5]

- 2 Fig. 1.1 shows a flower.



Fig. 1.1

Make a large drawing of the structures of the flower shown within the box on Fig. 1.1.



[4]

- 3 (a) Fig. 2.1 shows a section through part of a dicotyledonous leaf, as seen using a microscope.

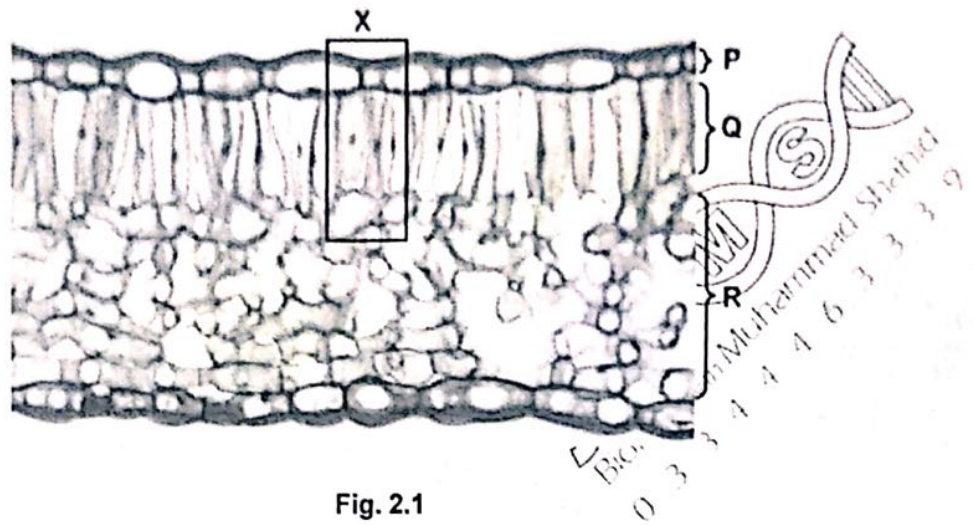
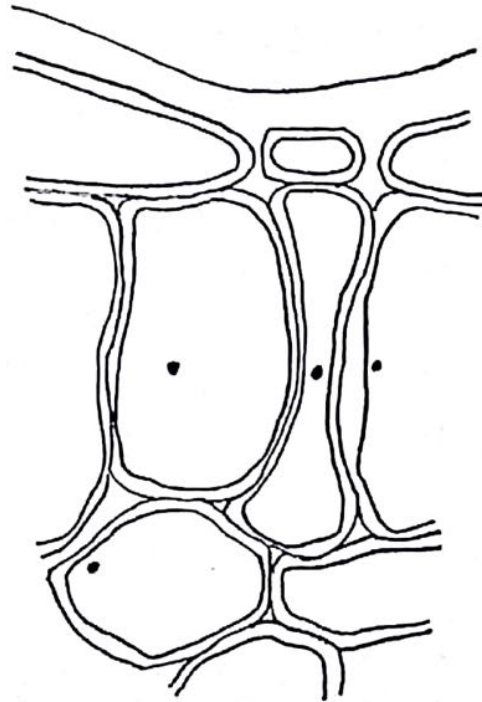


Fig. 2.1

- (ii) In the space below, make a large drawing of the cells in the box labelled X in Fig. 2.1. You do not need to label your drawing.



[3]

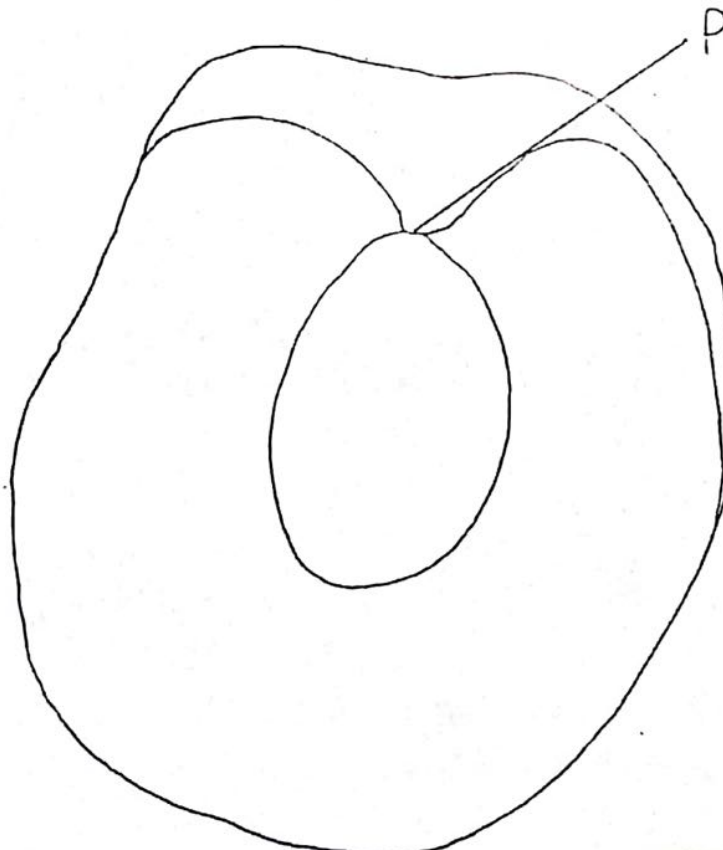
- 4 (b) Fig. 1.2 shows half of a fresh apricot.



Fig. 1.2
magnification $\times 1$

Make a drawing of this fruit, twice the size of the actual fruit.

On your drawing, indicate where the fruit was attached to the parent plant using the letter **P**.



- 5 Vegetarian sources of protein, for example seeds and single cell proteins, are increasingly being used throughout the world.

Fig. 2.1 shows the surface view of half of a peanut seed with the embryo attached.

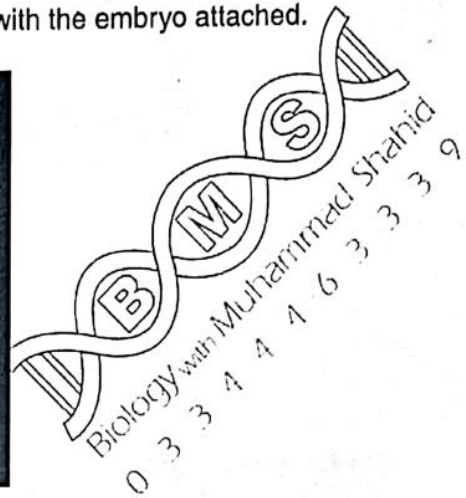
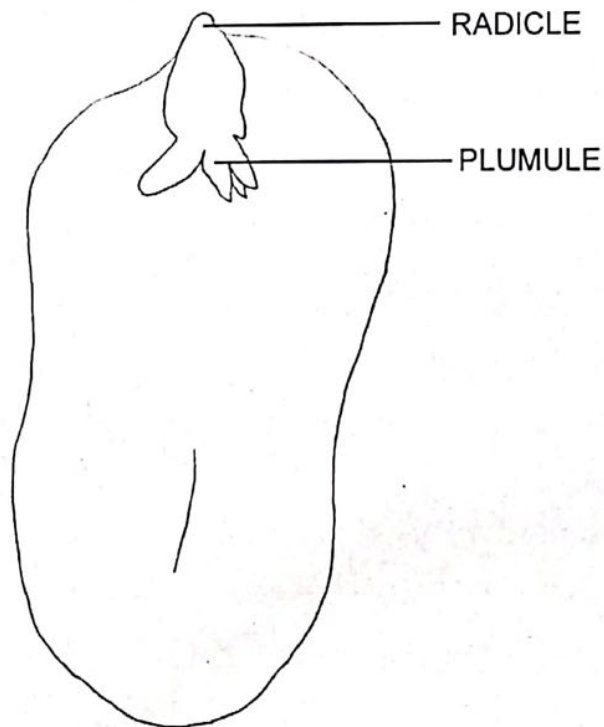


Fig. 2.1

- (a) Make a large drawing of the peanut seed as shown in Fig. 2.1. Label the radicle and plumule.



[4]

- 6 Fig. 2.1 shows blood cells as seen using a light microscope.

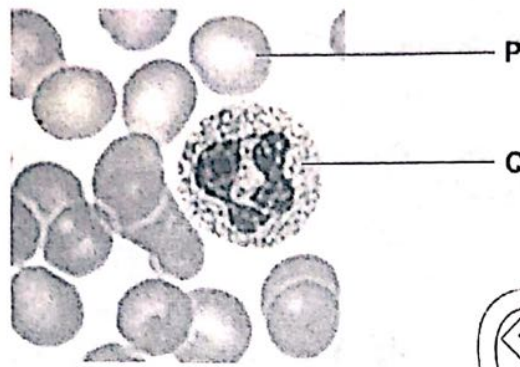
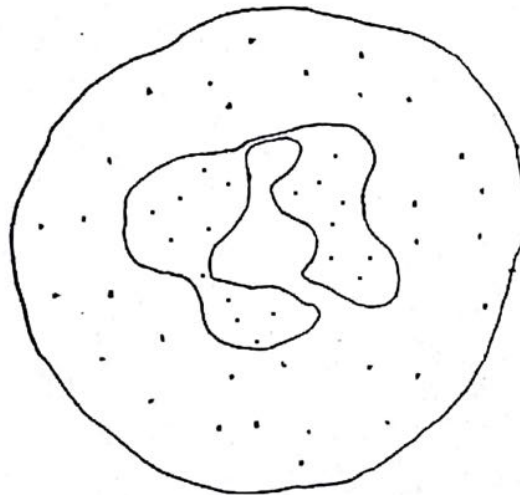


Fig. 2.1

- (a) In the space below, make a drawing of the cell labelled **Q** in Fig. 2.1, magnified $\times 2$. You do not need to label your drawing.



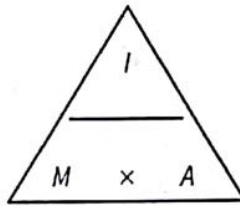
[4]

Drawing and Magnification

How to work out magnification and other sizes of drawings/Images

Magnification is the measure of how much larger the image is as compared to the actual size of the object. Formula to calculate magnification is given below.

$$M = \frac{I}{A}$$



In simple cover-up the value you wanted to find.

Where **I** is the observed size of the image, means that is what students measure with the ruler and **A** is the actual size of the organism. Both **I** and **A** are usually given or measured in **mm** (millimeters). Magnification is measured in **times** or represented with **X**. Don't forget to mention units throughout your calculations.

Take an example

Assume that in Fig.2.1 the size of the leaf is 5mm and your drawing is of 10 mm in size so calculating the magnification would be like:

Given

Size of the leaf = 5 mm

Size of the drawing = 10 mm

Find

Magnification

Solution

As

By putting values Magnification = $\frac{10 \text{ mm}}{5 \text{ mm}}$

$$\text{Magnification} = \text{X}2$$

(X represents **times**, which is the unit of magnification)

In above given example the calculation is simple.

In other cases magnification is already given (X500) and magnified image is also shown (suppose distance between Y - Y is 10mm). Calculation the actual length or size require just rearrangement of the formula.

$$\text{Magnification} = \frac{\text{observed size of the image /drawing}}{\text{actual size of the part}}$$

Rearrange formula

$$\text{Actual size of the part} = \frac{\text{observed size of the image /drawing}}{\text{magnification}}$$

Now put the values

$$\text{Actual size of the part} = \frac{10 \text{ mm}}{X 500}$$

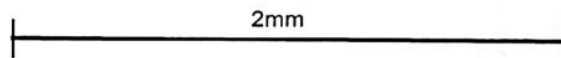
$$\text{Actual size of the part} = \frac{10 \text{ mm}}{X 500}$$

$$\text{Actual size of the part} = 0.02 \text{ mm}$$

Same sort of strategy would be applied to this question as well.

We can calculate the magnification of the specimen using a scale bar. the value mentioned above scale bar represent the actual size of specimen.

Measure the length of the scale bar and then apply the formula.

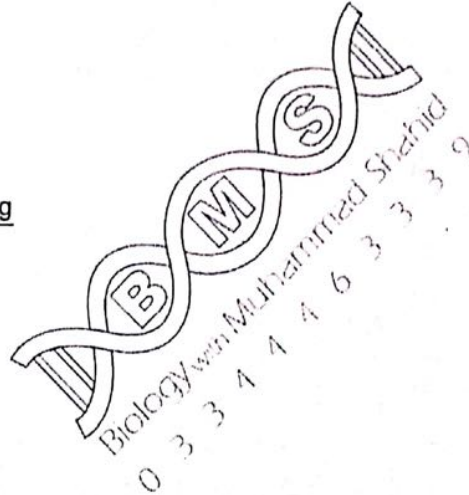


$$\text{Magnification} = \frac{\text{observed size of the image /drawing}}{\text{actual size of the organism or part}}$$

$$\text{Magnification} = \frac{80 \text{ mm}}{2 \text{ mm}}$$

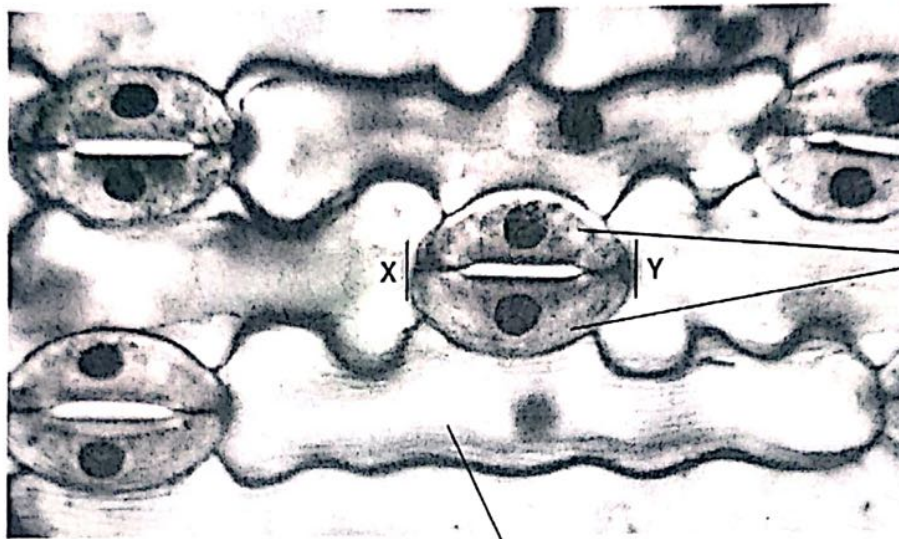
$$\text{Magnification} = X40$$

supposed values added in all formula



Worked Solution

- 1 (b) The photomicrograph shows a part of the surface of the epidermis of a leaf.

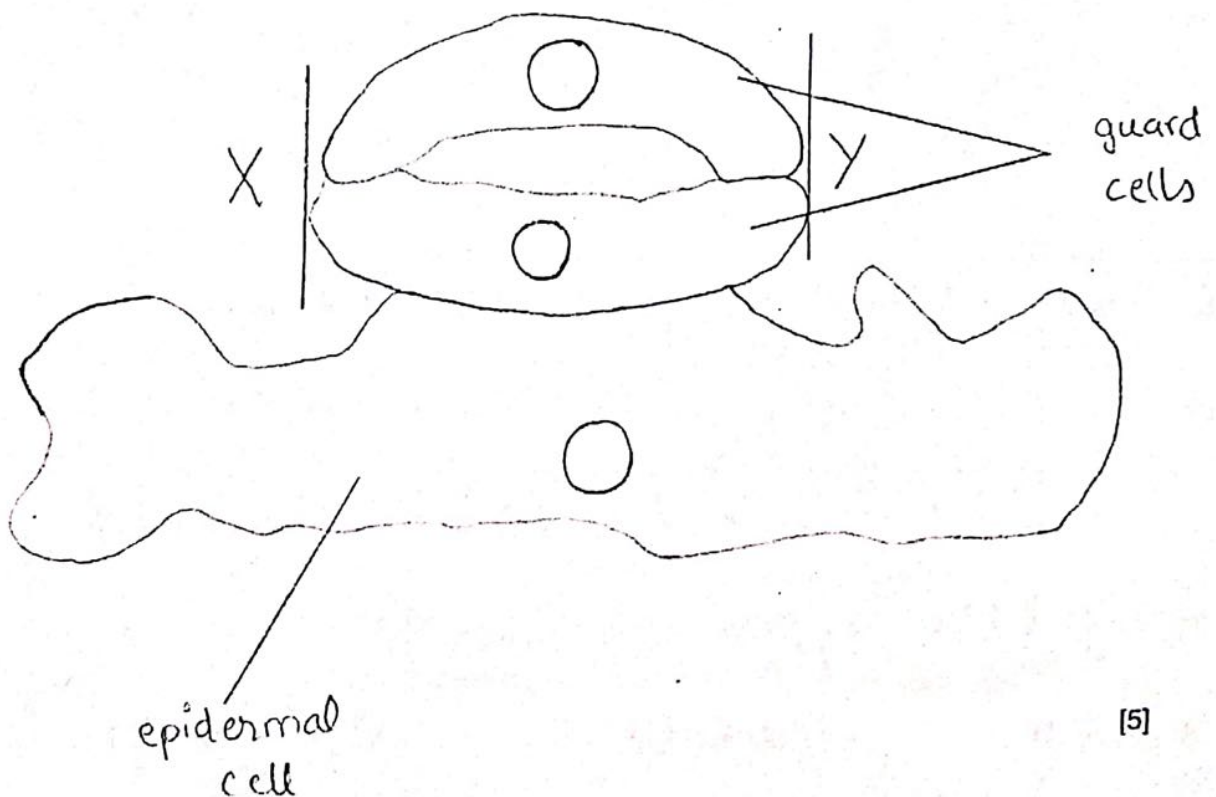


guard cells

epidermal cell

magnification $\times 800$

In the space below make a large drawing of the cells labelled 'guard cells' and 'epidermal cell' as they appear in the photomicrograph.



[5]

- (c) (i) Measure and record the maximum length of the guard cells between X and Y on the photomicrograph.

..... 32 mm

Draw a line in the same position on your drawing.

Measure and record the length of this line.

..... 66 mm
[3]

- (ii) Use your measurements in (c)(i) to calculate the magnification of your drawing compared to the actual size of the guard cells between X and Y.

Show your working.

$$\text{Magnification} = \frac{\text{Image}}{\text{Actual}}$$

$$= \frac{66 \text{ mm} \times 800}{32 \text{ mm}} \times \dots 1650 \dots [3]$$

[Total: 15]

$$= 1650$$

- 2 Fig. 3.1 shows two bones from the arm of a human.

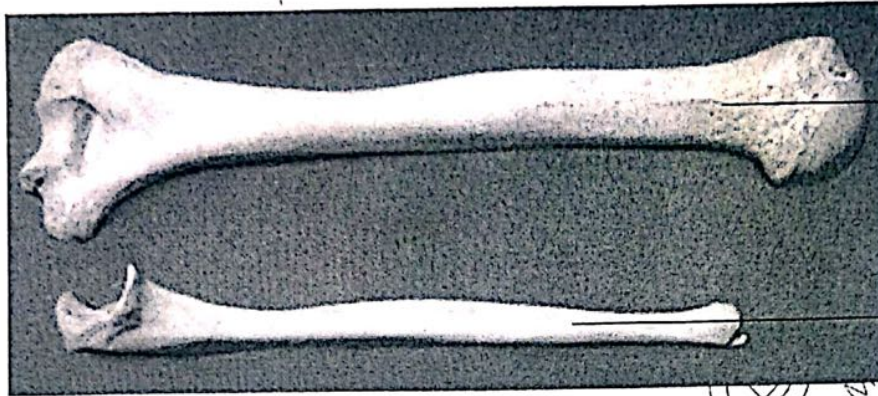


Fig. 3.1

- (a) Identify the bones labelled A and B

A

B

[2]

- (b) In the space below, make a drawing of the bone labelled B. Your drawing should be the same size as the bone in Fig. 3.1. You do not need to label your drawing.



[3]

- (c) (i) Measure and record the length of the bone labelled B in Fig. 3.1.

length of bone B = 95 mm [1]

- (ii) The actual length of this bone is 243 mm. Use your measurement in (c)(i) to calculate the magnification of Fig. 3.1.

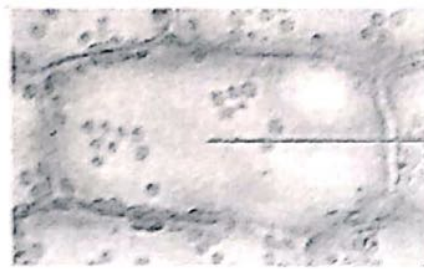
Show your working.

$$\text{magnification} = \frac{\text{image}}{\text{actual}}$$

$$m = \frac{95 \text{ mm}}{243 \text{ mm}}$$

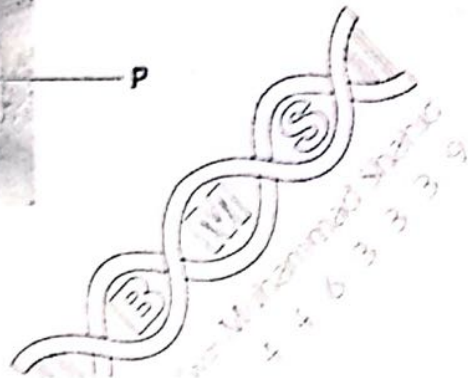
magnification x 0.4 [2]

- 2 Fig. 3.1 shows cells as seen using a light microscope.

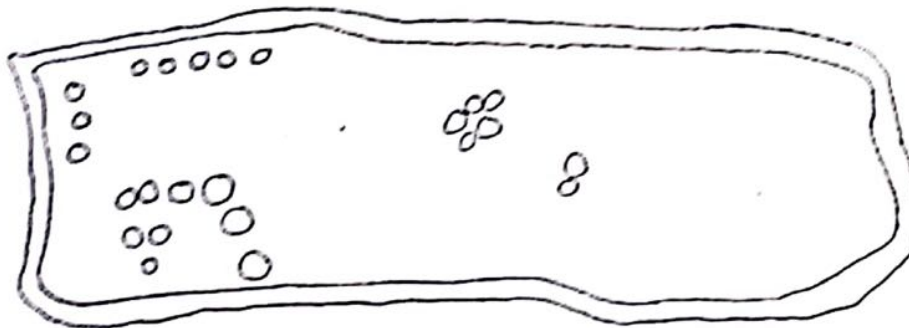


magnification $\times 200$

Fig. 3.1



- (a) In the space below, make a large drawing of the cell labelled P. You do not need to label your drawing.



[4]

- (b) Measure and record the maximum length of cell P in Fig. 3.1.

Maximum length of cell P in Fig. 3.1 48 mm

Use the magnification of Fig. 3.1 to calculate the actual length of cell P.

Show your working. $\text{magnification} = \frac{\text{Image}}{\text{Actual}}$

$$\begin{aligned} \text{so Actual} &= \frac{\text{Image}}{\text{magnification}} \\ &= \frac{48 \text{ mm}}{200} = 0.24 \text{ mm} \end{aligned}$$

[4]

- (c) State two structures, visible in Fig. 3.1, that are found only in plant cells.

1 Cell wall

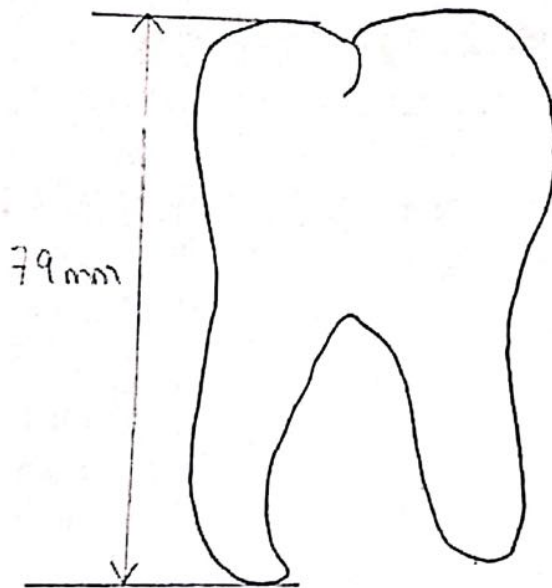
2 Chloroplasts

[2]

- 4 The photograph shows a human tooth.



- (a) In the space below make a large drawing of this tooth.



[4]

- (b) (i) Draw a line on the photograph to show the maximum length of the tooth.

Measure and record this length.

36 mm

Draw a line on your drawing to show the maximum length of the tooth.

Measure and record this length.

79 mm

[3]

- (ii) Use your measurements in (b)(i) to calculate the magnification of your drawing compared to the tooth in the photograph.

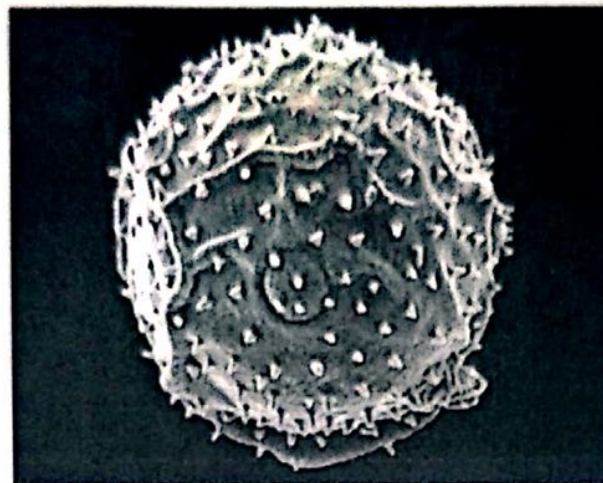
Show your working.

$$\text{Magnification} = \frac{\text{Image}}{\text{Actual}} = \frac{79\text{mm}}{36\text{mm}} = 2.194 \approx 2 \text{ times}$$

x 2

[2]

- 5 Fig. 3.2 shows a photomicrograph of a pollen grain from a marrow flower.



scale: |-----|
0.05 mm

Fig. 3.2

- (b) (i) Calculate the magnification of this pollen grain.

$$\text{Magnification} = \frac{\text{Image}}{\text{Actual}}$$

$$M = \frac{28 \text{ mm}}{0.05 \text{ mm}}$$

$$M = 540 \text{ times}$$

magnification **X 540**
.....[3]

6 Fig. 3.2 shows the locust in flight.

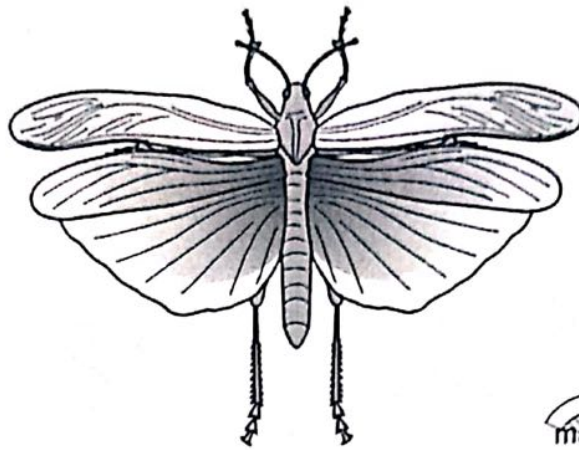


Fig. 3.2

Fig. 3.3 shows two other insects, an aphid and a fly.

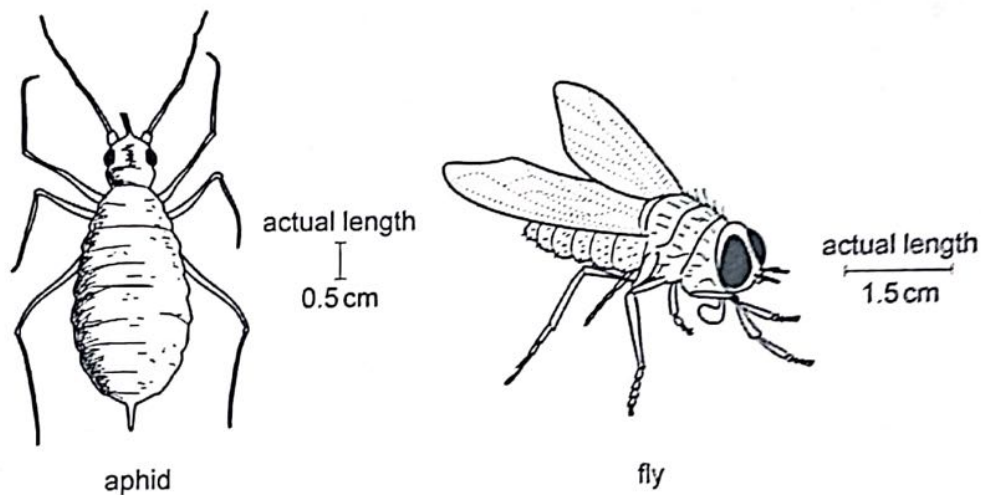


Fig. 3.3

(iii) Calculate the magnification of the drawing of the fly.

$$\text{Magnification} = \frac{\text{Image}}{\text{Actual}}$$

$$M = \frac{50 \text{ mm}}{15 \text{ mm}}$$

$$M = 3.3 \text{ times}$$

magnification X 3.3. [2]

Graph

Constructing and interpreting graph

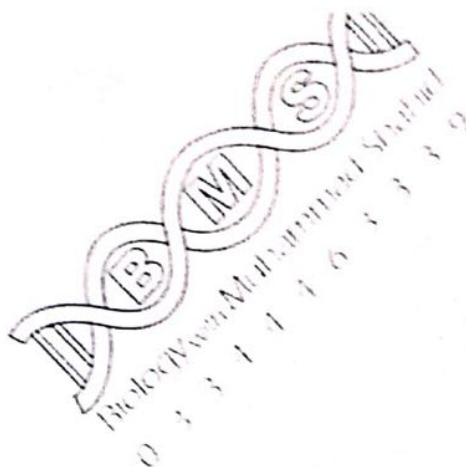
In questions related to graph keep **SLAP** in mind:

Suitable scale

Label the axis

Area, maximum grid used

Point, neither too big nor too small



- Don't forget to **label both X-axis and Y-axis**.
- Mention the **units** along with the labels.
- Data should be critically examined to established whether it is necessary to start the scale(s) at zero.
- Take **independent variable on X-axis and dependent variable on Y-axis** (Here in this example time is independent variable as with the passage of time surface area is depending on it).
- Make almost a **complete use of grid** don't leave a significant proportion of it blank and never restrict your working to a single corner of the grid. For this calculate your scales both for X-axis and Y-axis. Lets have a look at the working for X-axis scale
Find the range by deducting the minimum value from maximum value, like 30 sec is the minimum time value and 120 sec is the maximum time value. So range is $120 - 30 = 90$ sec so overall its 90 sec time interval and on X-axis we have 7 larger boxes so simply divide 90 by 7 and answer is 12.85 to take it to nearest whole number like 13. Now each larger box is now of 13 sec. In the same way we can work for each smaller box by dividing 13 by 10 as each larger box contains 10 smaller boxes. In this way we will be having a closer idea of each smaller box value. Same is to be dome for Y-axis.
- While mentioning the points on the grid don't forget to either **encircle your points or marking a cross on each point**. If you mark only a point this means it's the part of your line not a separate point as line is the combination of several points. At the same time remember that the size of dot (.) and encircle or cross (x) must not exceed the size of the smallest square on the grid.
- Follow the instructions and make curve if asked so or just join your points with the ruler as you are simply asked to make a graph. Strictly follow the instruction.
- If two graphs are to make on the same grid ensure that you use dots with circles around them for one graph and crosses for the other graph.
- In case of two graphs on the same grid label each graph so that examiner get to know which line represents which data etc.

Specific guidelines for a bar chart

Bar chart should be drawn when one of the variable is not a numerical value.

- If values on X-axis are numerical bar chart can be drawn.
- Lines or blocks should be of equal width.
- Data can be arranged in any direction.
- Mention the title on each axis.
- The values on the X-axis should be given in the middle of each bar.

Specific guidelines for a histogram

Histogram should be drawn when plotting frequency graphs with continuous data.

- Put frequencies on Y-axis and label it 'frequency'.
- On X-axis place the lower value of each interval.
- Draw a bar extending from lower value of each interval to the lower value of next interval.
- The blocks boundary should be touching each other.

Specific guidelines for a line graph

Follow the instructions if any given in the question statement otherwise you can make free hand, ruled line or best fit line. Any point away from trend in data can be omitted.

Specific guidelines for a pie chart

These should be drawn with the sectors in rank order, largest one first, beginning from the top and proceeding clockwise. Pie charts should ideally contain more than six sectors.

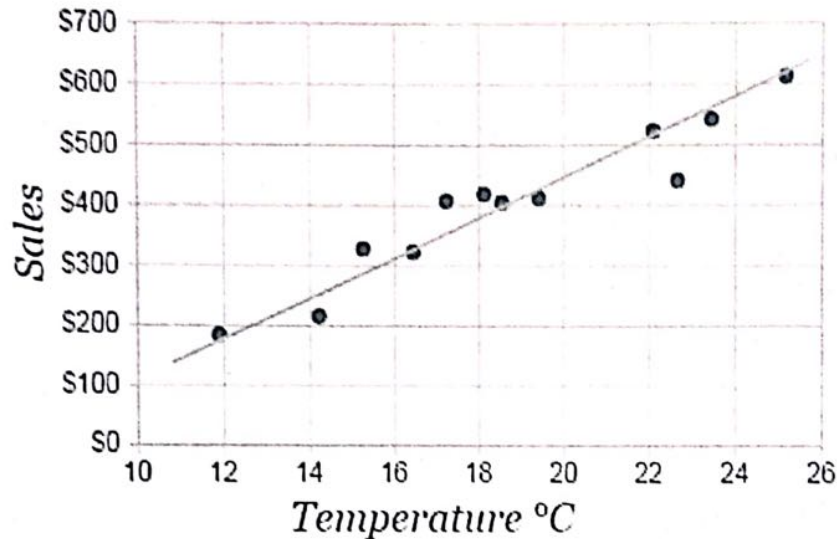
Represent each part of the data as proportion of 360. Because there are 360 degrees in a circle.

Take an example:

If 55 out of 270 vehicles are vans then we will represent this on the circle as a segment with an angle of $(55 / 270) \times 360 = 73$ degree.

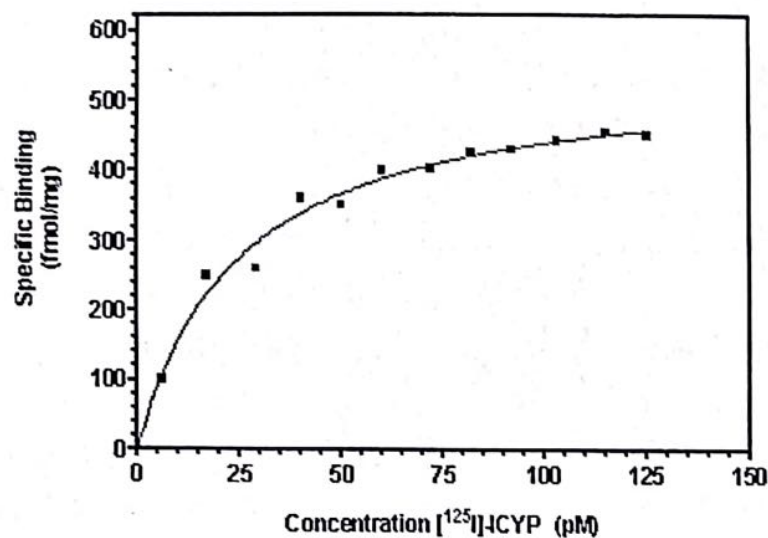
Line of Best-fit

This must be a single thin line or a smooth curve. It may not go through all of the points but it should have roughly half the number of points on each side of the data scattered. Ignore any anomalous data when you draw best-fit line.



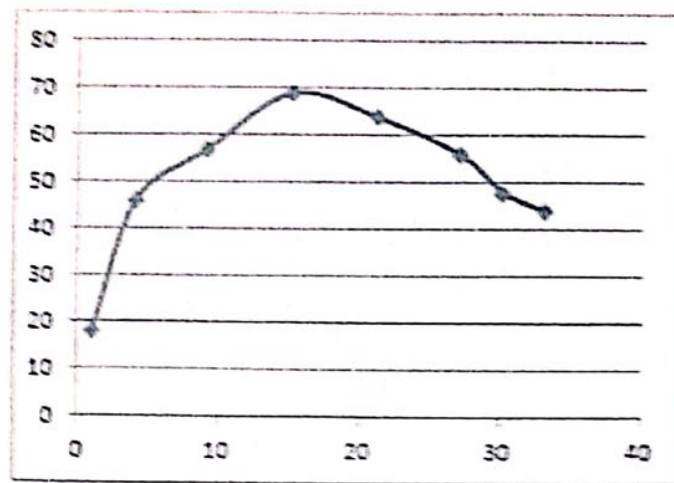
Curve of best fit / Curved line of best fit

While drawing curve of best fit/curved line of best fit, joining all points is not necessary



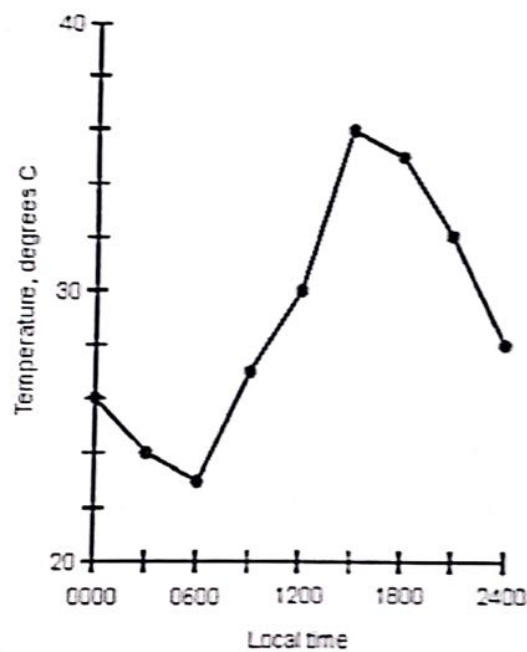
Smooth Curve

To draw a smooth curve join all points with free hand line but NOT with ruler.



Ruled Line

If instructed for a ruled line graph join the consecutive points with the ruler.



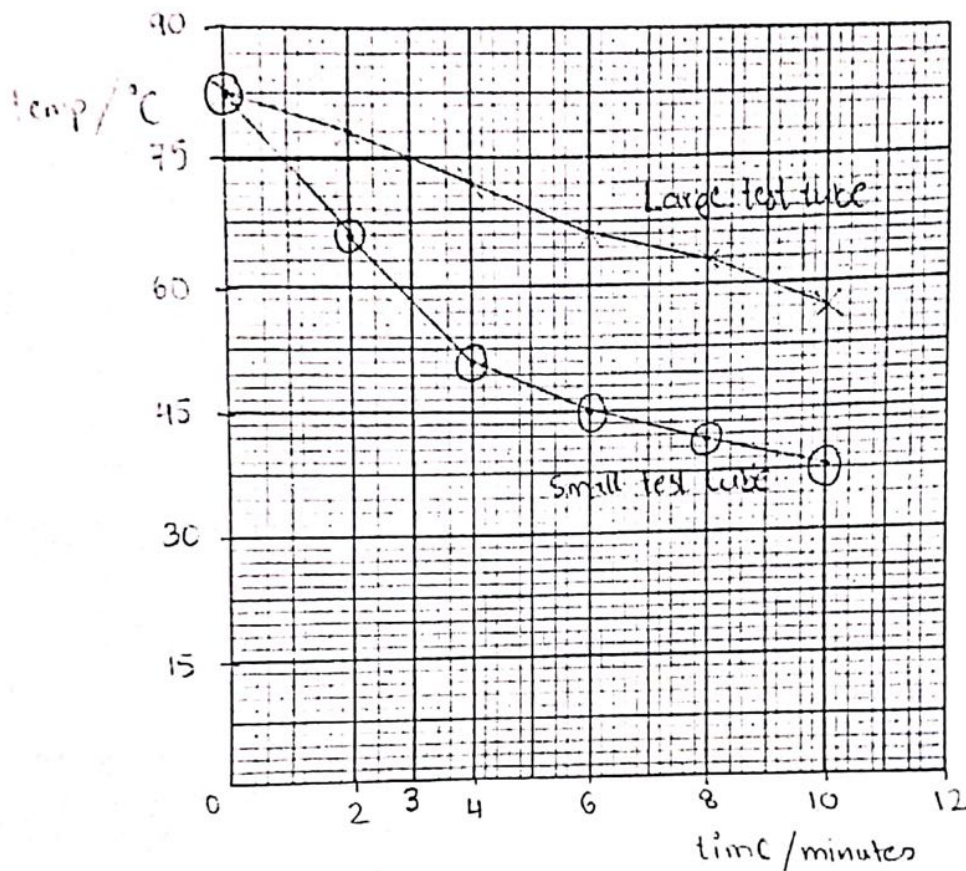
Worked Solution

- 1 A student wants to investigate heat loss from the outer surface of the bodies of two animals. She uses two test-tubes to represent the animals:
- a large test-tube with a lower surface area to volume ratio,
 - a small test-tube with a higher surface area to volume ratio.
- She pours hot water to almost fill each test-tube. Immediately she reads the temperature of the water in each test-tube and records the results.
 - She reads and records the temperature of the water in the test-tubes every 2 minutes for the next 10 minutes.
 - Her results are shown in the table.

time /minutes	temperature /°C	
	large test-tube	small test-tube
0	85	85
2	77	66
4	71	51
6	66	45
8	61	41
10	58	38

- (b) (i) On the grid below and using **one set of axes**, construct a graph with **two lines** to show the relationship between time and temperature of the water in the two test-tubes.

Join your points with ruled, straight lines.



X Large test tube

O Small test tube

- (ii) Use your graph to determine the temperature of the water in the large test-tube at 3 minutes.

Show your working on your graph.

..... 75°C [2]

- (iii) Describe what you can conclude about heat loss in large and small animals from the student's results.

I can conclude that there is more heat loss in smaller animals than larger ones. [1]

- 2 Some students wanted to investigate the effect of concentrated fruit juice on potato tissue. Fruit juice contains a lot of sugar.

Five different solutions A, B, C, D, and E were prepared from concentrated fruit juice and water as shown in Table 1.1.

- (a) Complete Table 1.1 by inserting the volumes of fruit juice and water required to prepare solution B.

Table 1.1

solution	volume of fruit juice used/cm ³	volume of water used/cm ³	fruit juice concentration/%
A	0	100	0
B	25	75	25
C	50	50	50
D	75	25	75
E	100	0	100

[1]

Five pieces of fresh potato were cut to 70 mm in length. One piece was placed in each of the five solutions so that each piece was fully submerged. They were left for 40 minutes and then removed.

Fig. 1.1 shows the appearance of these five pieces of potato after 40 minutes.

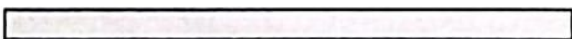
solution	pieces of potato in side view
A	
B	
C	
D	
E	

Fig. 1.1

- (b) (i) Measure the length of each piece of potato in Fig. 1.1 and record your measurements in Table 1.2.

Table 1.2

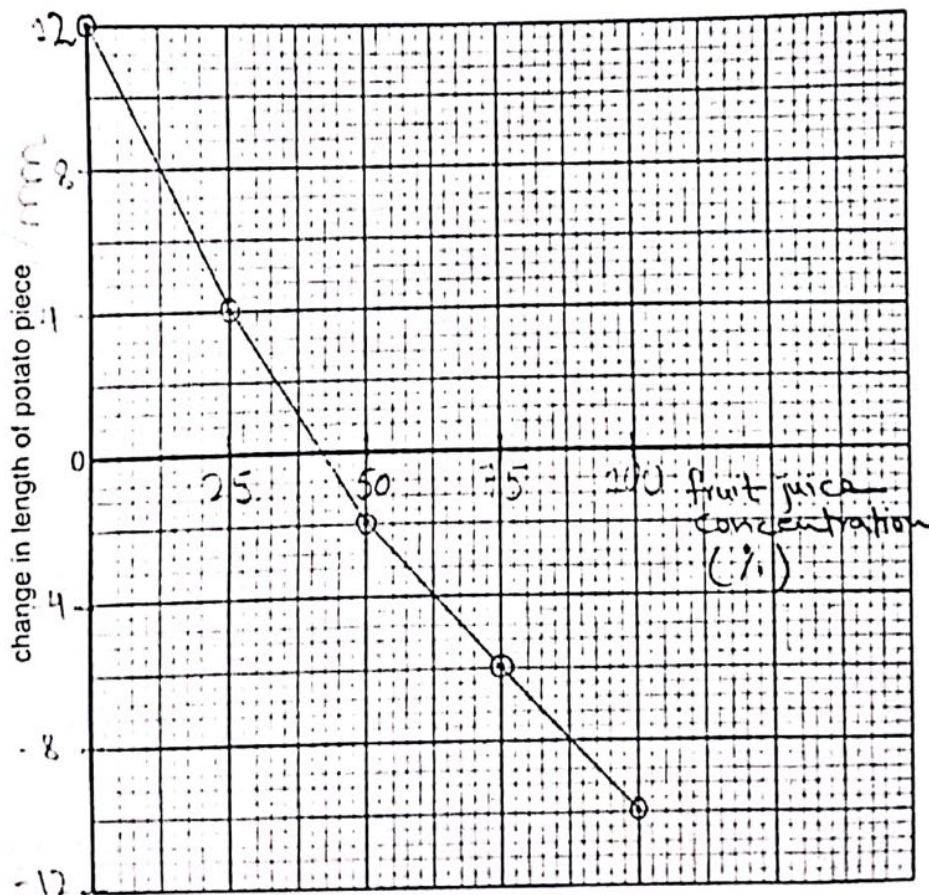
solution	fruit juice concentration/%	final length of potato piece/mm	change in length of potato piece/mm
A	0	82	12
B	25	74	4
C	50	68	-2
D	75	64	-6
E	100	60	-10

[2]

- (ii) Complete the last column in Table 1.2 by recording the change in length of each piece of potato. [3]

- (iii) Construct a graph to show the effect of fruit juice concentration on change in length of potato pieces.

Complete the labelling of the axes.



[5]

- 3 (a) Catalase is an enzyme found in many tissues. Catalase breaks down hydrogen peroxide, forming water and oxygen.

Fig. 1.1 shows the apparatus used by a student to investigate the effect of pH on the activity of catalase. The gas syringe was used to measure the volume of oxygen produced at each pH.

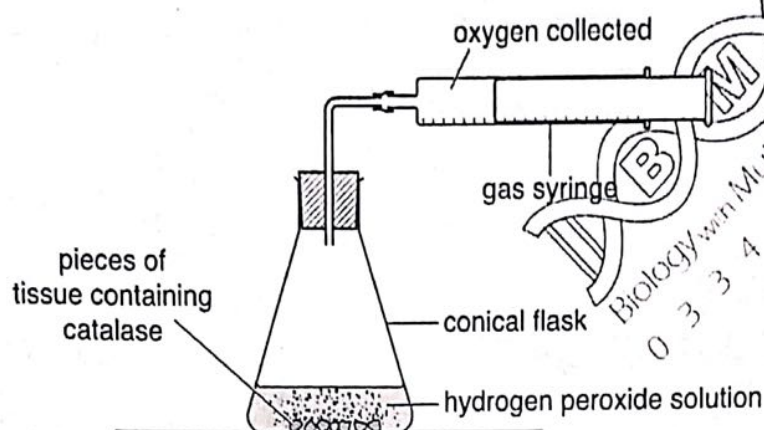


Fig. 1.1

The student carried out the experiment at a pH of 7.0 and measured the volume of oxygen produced during a period of five minutes.

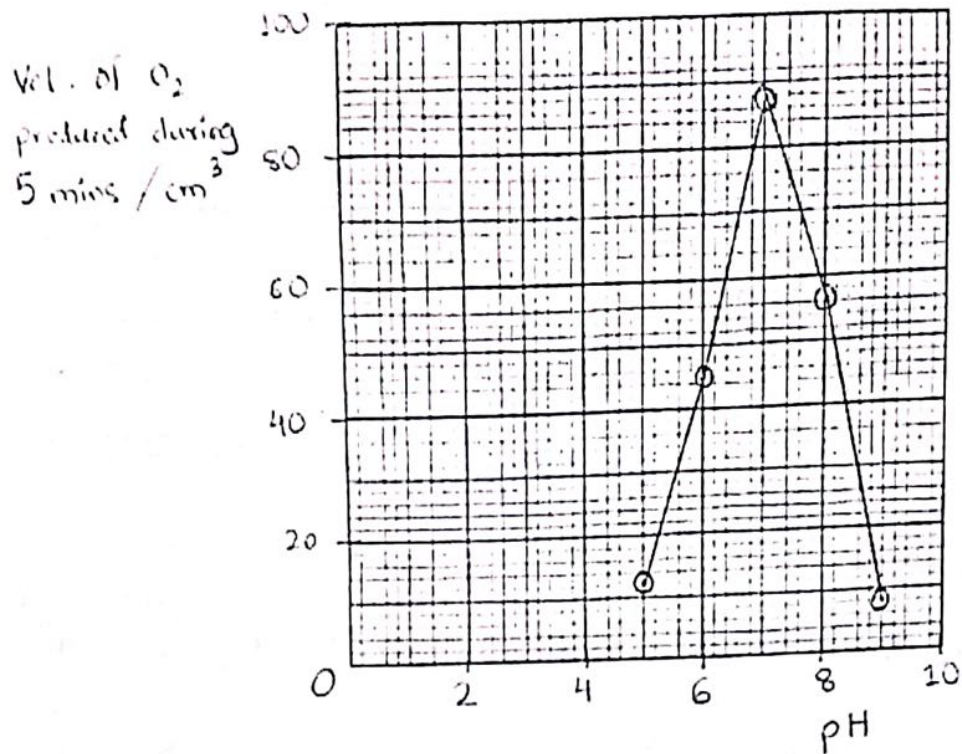
He then mixed fresh samples of tissue containing catalase, and hydrogen peroxide solution at pH values of 5.0, 6.0, 8.0 and 9.0 and measured the volume of oxygen produced during five minutes for each pH.

The results are shown in Table 1.1.

Table 1.1

pH	volume of oxygen produced during five minutes/cm ³
5.0	12
6.0	45
7.0	88
8.0	57
9.0	8

- (i) Using the data in Table 1.1, plot a line graph to show the effect of pH on the activity of catalase.
Join the points on your graph with ruled, straight lines.



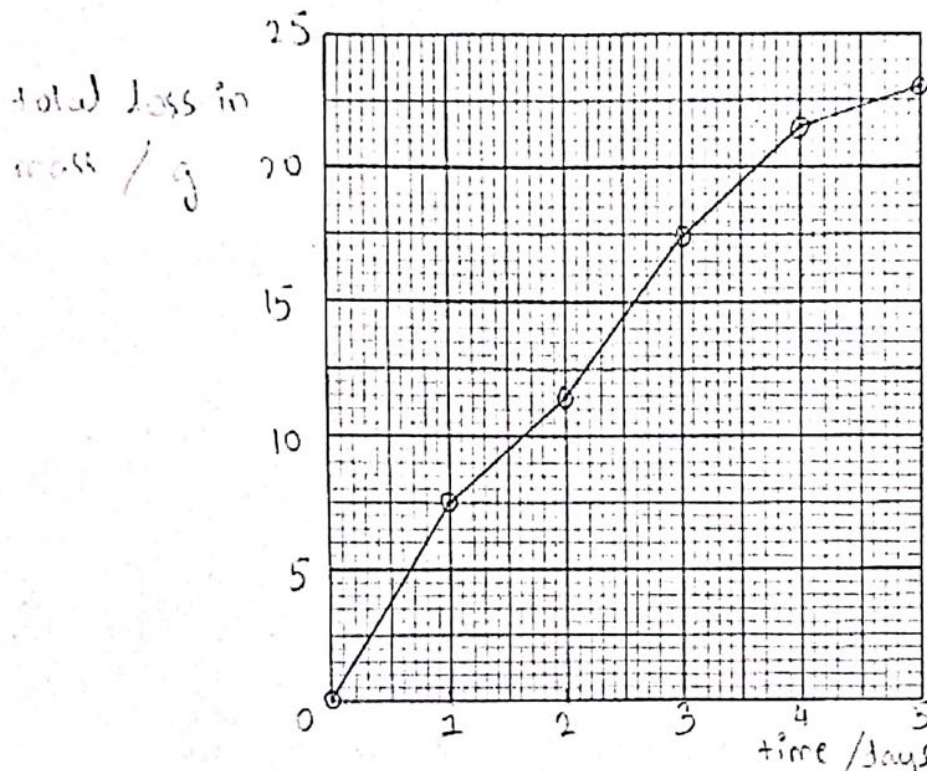
- 4 (d) Fruits, such as apricots, can be preserved by drying them in the sun.

Some students investigated the changes in mass of some fruits as they were left to dry over five days. The results are shown in Table 1.2.

Table 1.2

time/days	mass/g	total loss in mass/g
0	30.0	0.0
1	22.5	7.5
2	17.0	13.0
3	12.0	18.0
4	8.5	21.5
5	7.0	23.0

- (i) Calculate the total loss in mass/g for days 4 and 5 and complete Table 1.2. [2]
 (ii) Construct a graph to show the total loss in mass of the fruits with time.



[4]

- 5 Two students measured how good their reactions were by using a metre ruler as shown in Fig. 3.1. The reaction being tested was catching a falling metre ruler.

student 1 ready
to drop the metre ruler

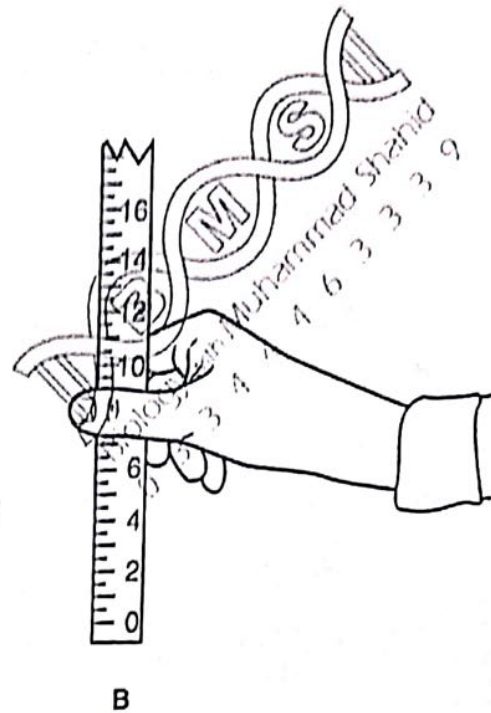
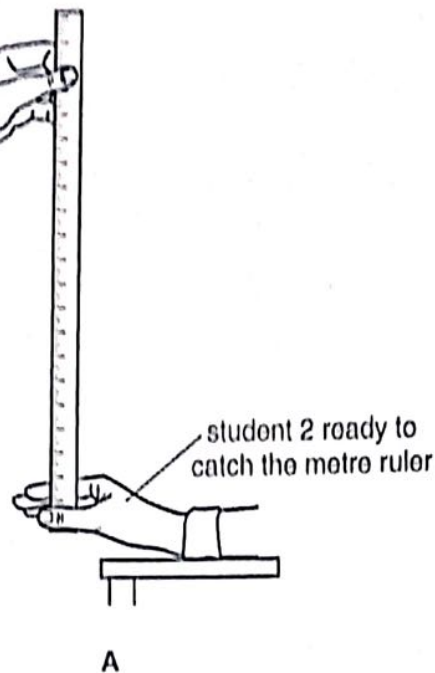


Fig. 3.1

Student 1 held the metre ruler near the 100 cm end so that when they let it drop, student 2 would be able to catch it between the thumb and fingers that were held open ready at the 0 cm end of the metre ruler. The measurement on the metre ruler where it was caught by student 2 was recorded. The students then swapped so that student 2 dropped the ruler and student 1 caught it. The ruler was dropped and caught a total of 5 times by each student.

The results obtained by the students were:

Student 1: 16.0 cm ; 12.0 cm ; 10.0 cm ; 15.0 cm ; 7.0 cm
Student 2: 18.0 cm ; 15.5 cm ; 12.0 cm ; 51.0 cm ; 12.5 cm

(a) (i) Draw a table that could be used to display these results.

	Reading 1	2	3	4	5
Student 1	16.0	12.0 _{cm}	10 _{cm}	15 _{cm}	7 _{cm}
Student 2	18.0 _{cm}	15.5 _{cm}	12.0 _{cm}	51.0 _{cm}	12.5 _{cm}

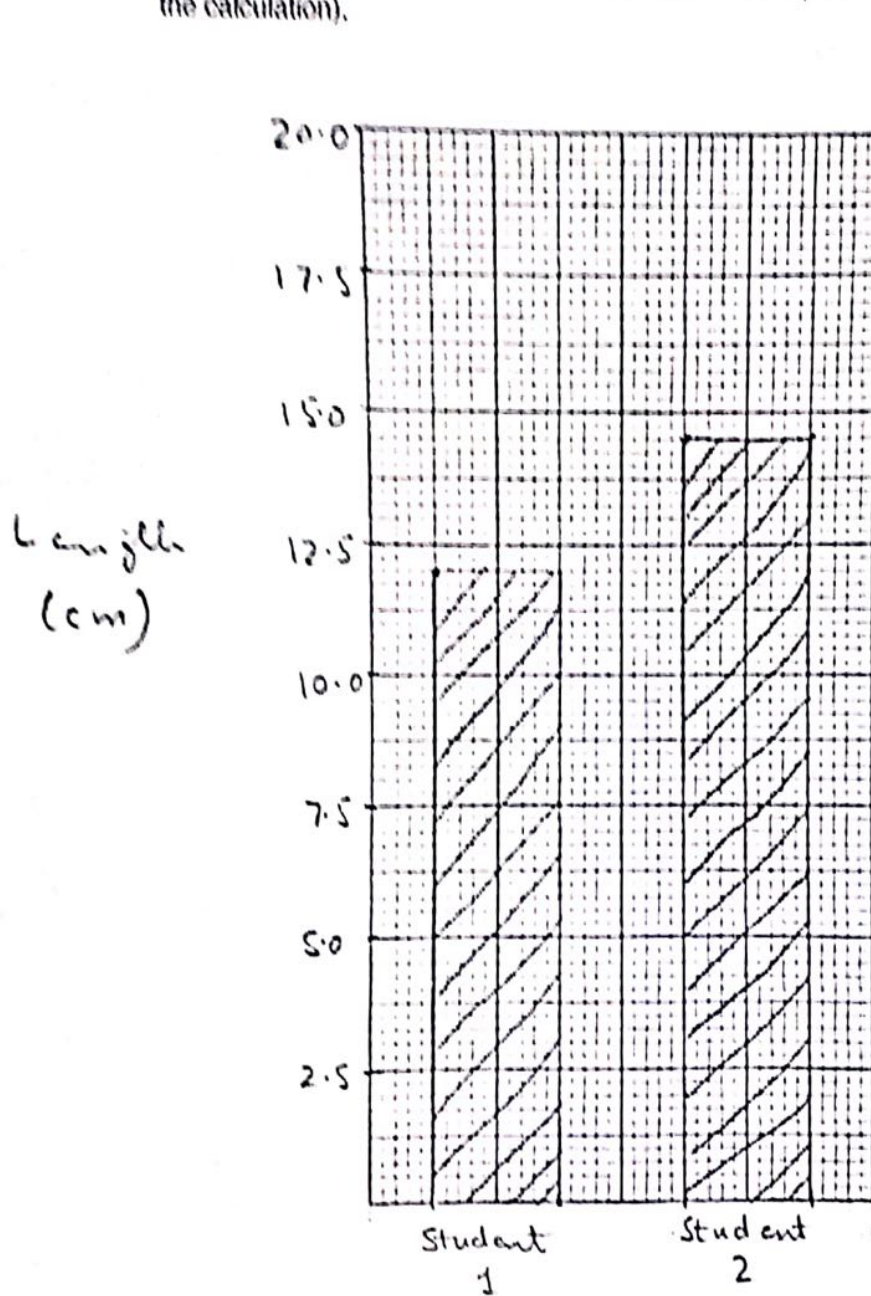
[3]

(ii) Calculate the mean result for student 1.

.....12..... cm [1]

- (v) Construct a bar chart of the mean results obtained for the two students.

The mean result calculated for student 2 was 14.5 cm (omitting the 51.0 cm reading from the calculation).



[3]

[Total: 9]

- 6 (c) Yeast is used for the production of alcohol in the brewing industry.

In an investigation, the production of alcohol by yeast was recorded every 5 hours for 25 hours.

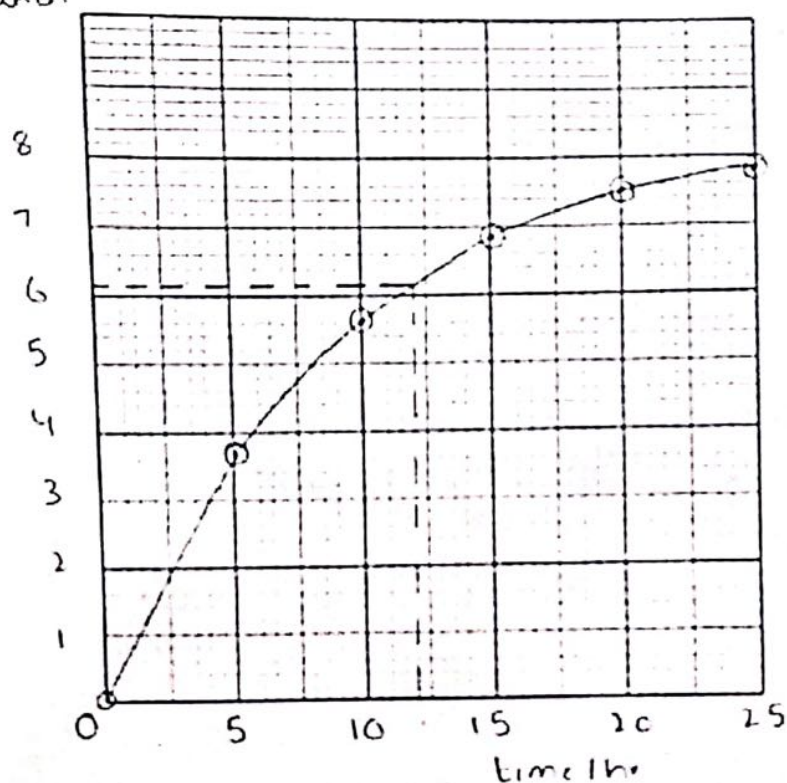
The results are shown in Table 1.2.

Table 1.2

time /hr	alcohol concentration /g per dm ³
0	0.0
5	3.7
10	5.6
15	6.8
20	7.5
25	7.8

- (i) Construct a line graph of the data in Table 1.2 on the grid below.
Draw a smooth curve through your points.

alcohol concentration
gram/dm³



[4]

- (ii) Use your graph to find the concentration of alcohol after 12 hours.

concentration = 6.2 g/dm³ [2]

- 7 (b) An investigation was carried out to discover what happens to the vitamin C in cabbage leaves during cooking.

100g of fresh cabbage leaves were cut up, placed into boiling water and left to continue boiling for 10 minutes.

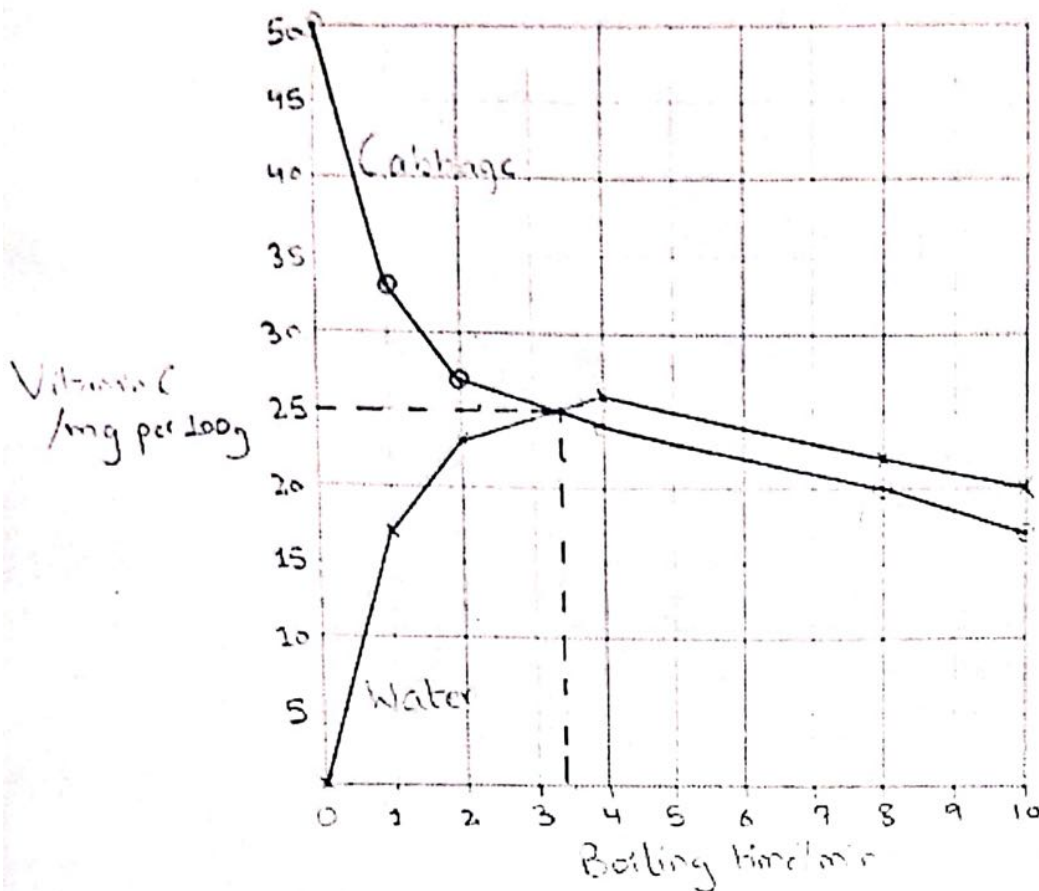
Samples of cabbage leaves and of the water they were boiled in were taken at intervals, cooled, and the vitamin C content was measured.
There is no vitamin C in clean water.

These measurements are shown in Table 1.1.

Table 1.1

boiling time / min	vitamin C / mg per 100g	
	cabbage	water
0.0	50.0	0.0
1.0	33.0	17.0
2.0	27.0	23.0
4.0	24.0	26.0
8.0	20.0	22.0
10.0	17.0	20.0

- (i) Construct a graph of the data in Table 1.1.
Use the same axes for both sets of data.



[5]

- (ii) After boiling for 10 minutes only about one third of the vitamin C remained in the cabbage leaves.

Use your graph to find the time at which the vitamin C content in cabbage had fallen to half.

Show your working.

3 minutes 24 secs

answer ...3 minutes 24 secs..... [2]

Food Tests

▪ Carbohydrates

Carbohydrates presence can be confirmed by reducing sugars and starch testing.

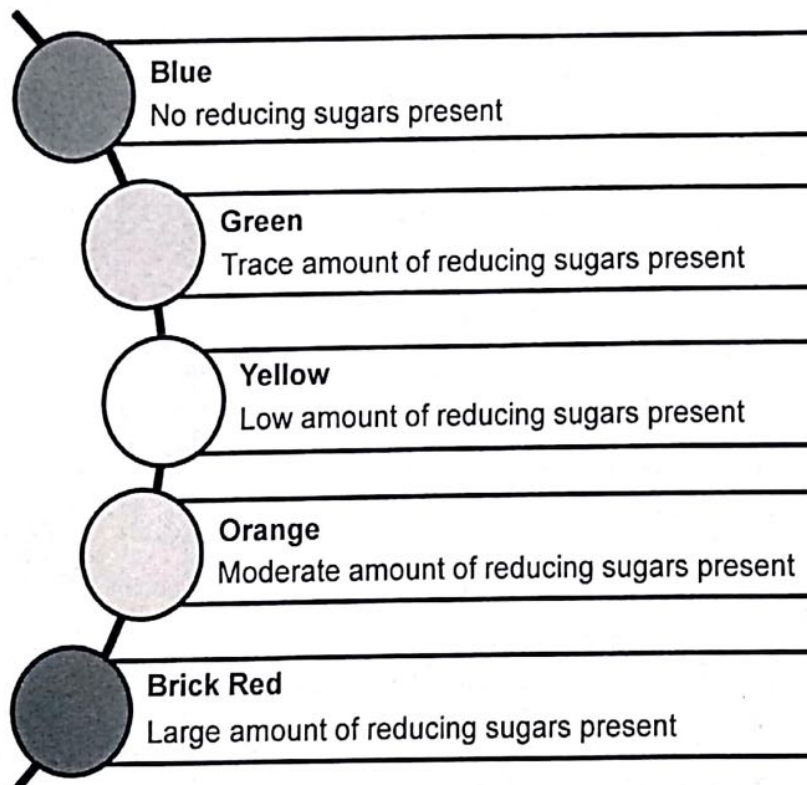
Starch

In order to test the presence of starch in food sample, add few drops of **iodine solution** to that sample. If color of iodine changes from **yellow/brown** to **blue/black**; that indicates positive test (meaning that starch is present in sample). But if iodine solution retains its color (yellow/brown); that indicates negative test (meaning that starch is not present in sample).

Reducing Sugar

Reducing sugars include maltose and glucose. For checking the presence of reducing sugars we apply **benedict's solution** test. Add equal volume of Benedict's solution to the food sample. Heat the sample to 90 °C (test tube) in water bath for 5 min. Observe the color changes from **blue** to **green, yellow, orange, and brick red**.

The intensity of color darkness relates the concentration of reducing sugars present in sample.



- **Proteins**

Protein presence in a food sample can be judged with **biuret solution**. Add equal volume of biuret solution to the food sample. Shake gently and observe the color changes from **blue to purple/violet** if proteins are present in sample (positive test). But if color of solution stays blue, then no proteins are present in sample (negative test).

- **Fats**

Presence of fats can be tested with **ethanol**. Preferably a dried food sample is mixed with ethanol; solution stays clear. Now pour that solution to a test tube containing water. If fats are present in sample, then solution will turn **cloudy** (positive test). But if stays clear, then no fats are present in sample (negative test).

Remember! If food sample is wet then on pouring ethanol; solution will turn cloudy (on presence of fats)

Worked Solution

- 1 (c) Ripe fruits contain reducing sugars.

Describe how you could test a sample of fruit to show that it contains reducing sugars. Include **one** safety feature in your method.

The sample of fruit could be crushed for larger surface area and fast speed of reaction. The sample of crushed fruit would then be put in a test - tube along with equal volume of Benedict's solution and heat it to 90° C for 5 min. in water bath. Observe the color change from blue to green, yellow, orange or brick red in case of presence of reducing sugar.

[4]

- 2 (a) Describe how you would test a food sample for the presence of each of the following, giving full experimental details.

- (i) starch Add few drops of iodine solution on the food sample to be tested.

In case of presence of starch, iodine will change its color from yellow/brown to blue/black.

[2]

- (ii) reducing sugars Add equal volume of Benedict's solution to the substance to be tested and heat it in a water bath at 90 °C. Either of red, orange, yellow or green color will be seen if a reducing sugar is present, blue color if it isn't present.

[3]

- 3 (a) Describe how you could test a peanut seed for the presence of protein.

Firstly, we will crush the peanut seed into smaller sizes. Then to test for protein we will add equal volume of biuret reagent and if the color of solution turns from blue to purple it will mean protein is present.

[3]

Water and Carbon Dioxide

Testing Presence of Carbon dioxide with Hydrogencarbonate Indicator

Hydrogencarbonate indicator is used to check the presence of carbon dioxide as it reacts to pH by changing colour.

- In natural conditions hydrogen carbonate colour is red
- In alkaline condition hydrogen carbonate colour is purple
- In acidic conditions hydrogen carbonate colour is yellow

As carbon dioxide is acidic in nature so the hydrogencarbonate indicator remains red if no carbon dioxide is present and the hydrogencarbonate indicator changes from red to yellow, if carbon dioxide is present.

Testing Production of Carbon dioxide with lime Water

Lime water remains clear if carbon dioxide is not produced but if carbon dioxide is added to it, it turns milky/cloudy.

Testing Presence of Water with Cobalt Chloride Paper

Cobalt chloride paper is used to check the presence of water.

Once cobalt chloride paper is dry its colour is blue but in presence of water its colour will change from blue to pink.

Worked Solution

- 1 The composition of inhaled air differs from that of exhaled air.

Complete Table 3.1 for water vapour in exhaled air and state the test for the presence of each of the three gases.

Table 3.1

	inhaled air	exhaled air	test
carbon dioxide	0.04%	4.0%	Turns lime water, milky
oxygen	21%	16.0%	Re-lights glowing splint
water vapour	variable – depends on environment	saturated	Turns cobalt chloride paper, blue to pink.

[7]

Features of a Photograph or Drawing

Recognizing and Observing Features of a Photograph or Drawing

In many of questions examiners ask students for mentioning **observable** or **visible** features of a drawing or process.

In other cases examiner ask students to **recognize** the structure on the basis of the visible structural features or the positioning of part identified.

If asked for drawing of the identified part use the same standards of drawing as mentioned earlier but in this case don't make the complete specimen instead follow the instruction and make the drawing of only specified/indicated area.

There are some cases that image might be unfamiliar but on the basis of structural adaptations and clues given in questioning help students to guess organisms. Again in this case keep you drawing restricted to only specified area.

Worked Solution

- 1 Figs. 2.1 and 2.2 show two different insects.

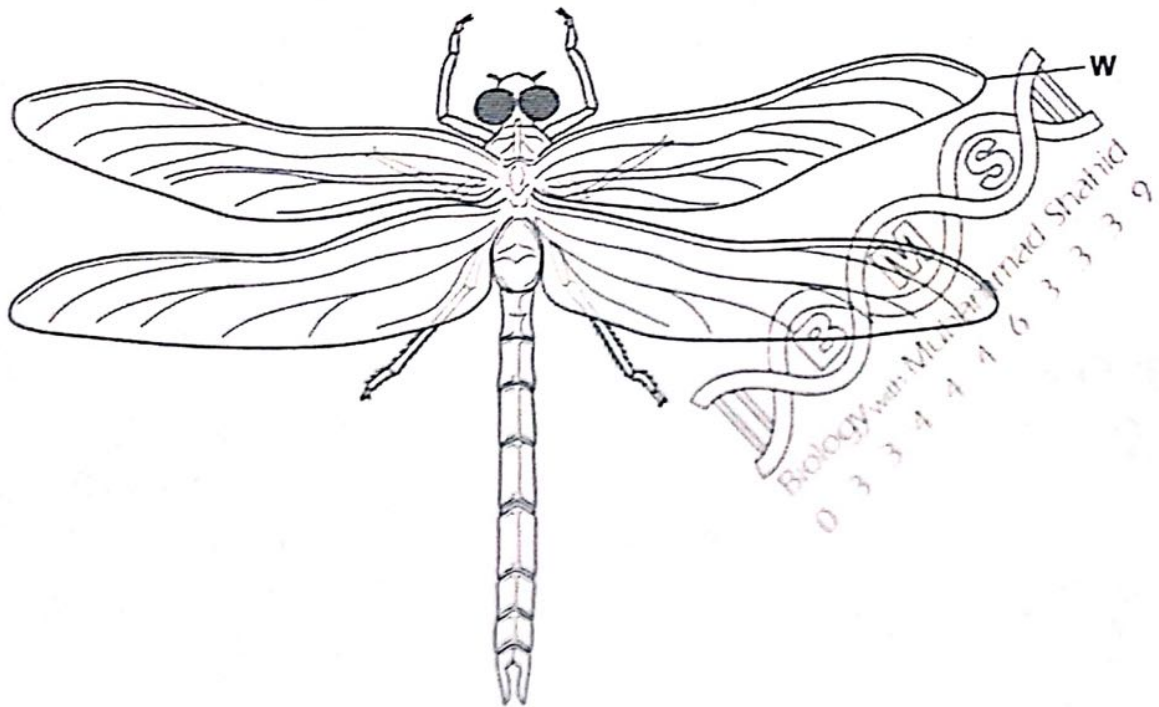


Fig. 2.1

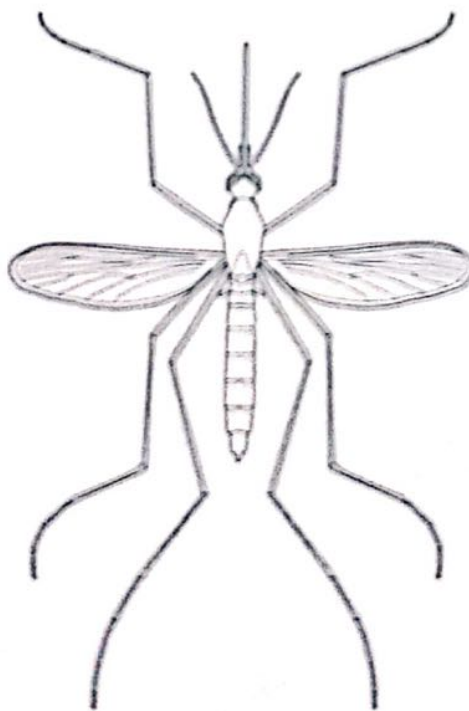


Fig. 2.2 (Not drawn to the same scale)

(a) List four **visible** features that are the same in both insects.

1. Wings

2. Antenna

3. Legs

4. Head

[4]

(b) Complete Table 2.1 with four pairs of differences that are **visible** in these insects.

Table 2.1

	feature in Fig. 2.1	same feature in Fig. 2.2
1	4 Wings	2 Wings
2	Hairy thicker legs	thinner and smoother legs
3	2 Hind legs; 4 forward legs	4 hind legs; 2 forward legs
4	Larger eyes	Smaller eyes

[4]

(c) In the specimen from which Fig. 2.1 was made, the length of the wing labelled **W** was 40 mm.

Calculate the magnification of the insect shown in Fig. 2.1.

Show your working clearly.

$$\text{Magnification} = \frac{\text{Image}}{\text{Actual}}$$

$$M = \frac{62 \text{ mm}}{40 \text{ mm}}$$

$$\text{magnification} = \dots \times 1.5 \dots [3]$$

[Total: 11]

- 2 Fig. 2.2 shows a section through a similar leaf as seen under a microscope.

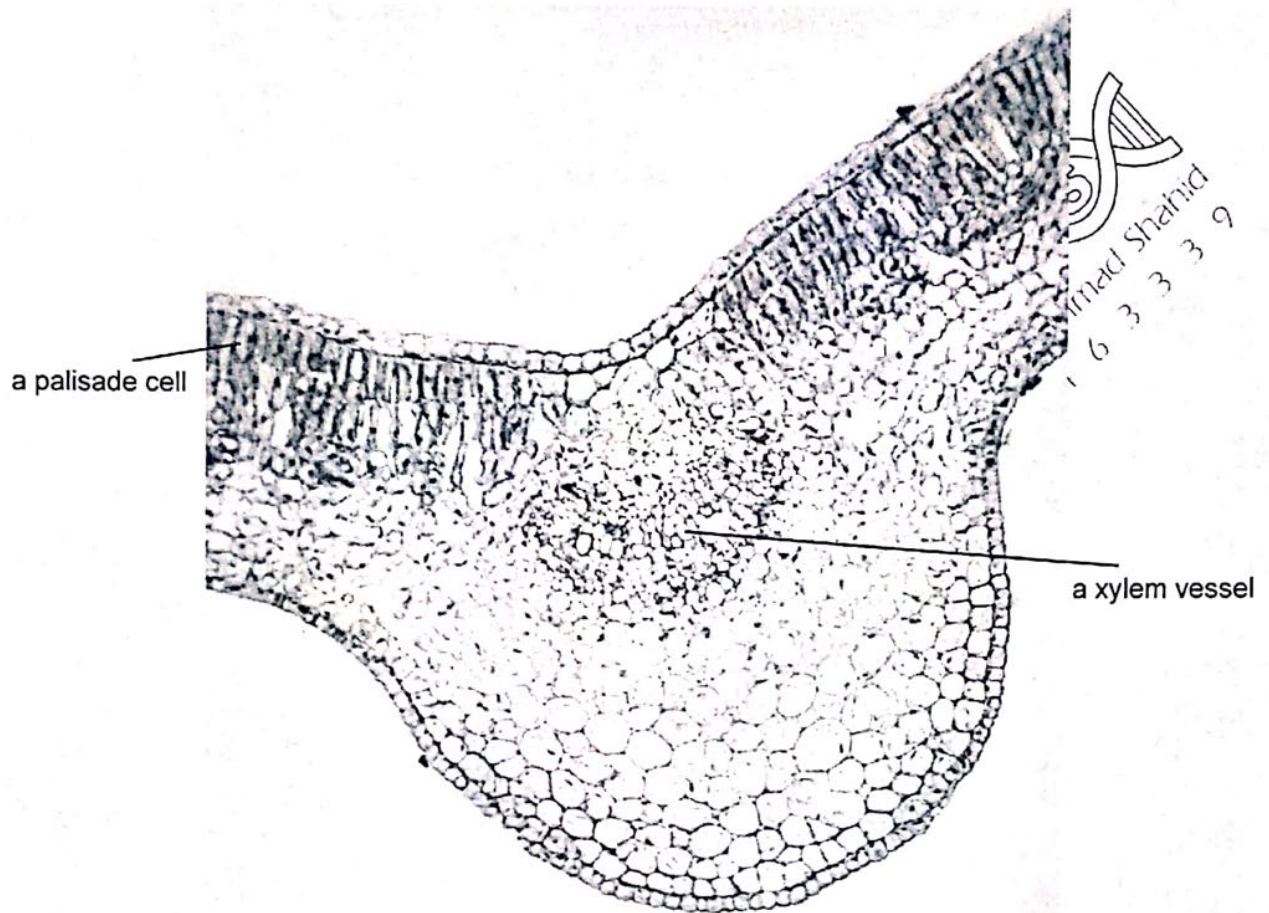


Fig. 2.2

(c) (i) On Fig. 2.2, using a labelling line, label and name each of the following:

- a palisade cell
- a xylem vessel

[2]

(ii) Describe a feature of each of these cells that is related to the function stated.

- a palisade cell for photosynthesis

feature Contains chloroplasts with chlorophyll which allows for photosynthesis.

- a xylem vessel for supporting the leaf

feature Contains lignin which makes it tough enough to support the leaf.

[2]

(iii) Explain how the position of the cell in the leaf is related to this stated function.

palisade cell It needs light for photosynthesis hence is located near the surface of the leaf.

xylem vessel In order to better support the leaf, it is in the midrib or center of the leaf.

[2]

[Total: 13]

Worked Solution

- 1 (i) Complete Table 2.2, to show the loss in mass, compared to the starting mass, for the sample of unwrapped apples.

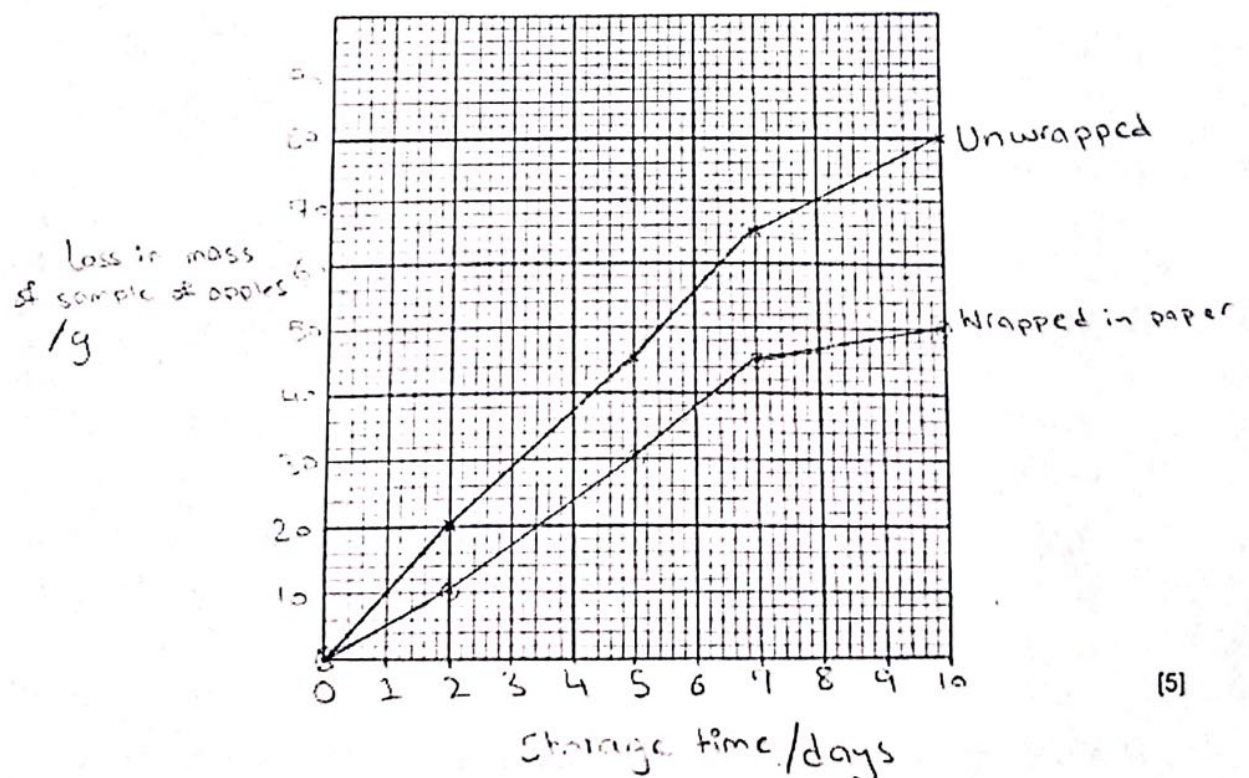
Table 2.2

storage time / days	loss in mass of sample of apples / g	
	wrapped in paper	unwrapped
0	0	0
2	10	20
5	30	45
7	45	65
10	50	80

[2]

- (ii) Construct a graph of the data in Table 2.2 to show the loss of mass of the wrapped apples and unwrapped apples.

Use the same axes for plotting both sets of data.



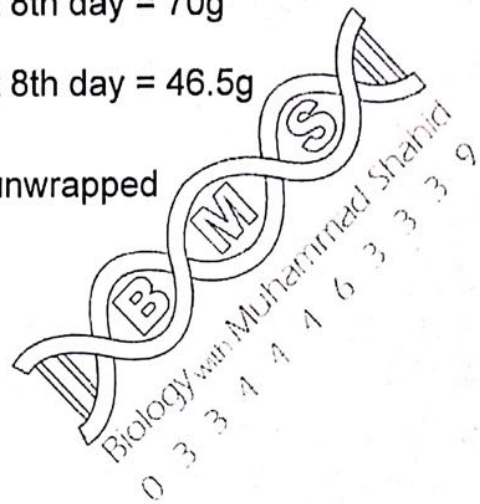
[5]

- (iii) Using your graph, calculate the difference in loss in mass between the unwrapped and wrapped apples after **8 days** of storage.

loss of mass of unwrapped apples at 8th day = 70g

loss of mass of wrapped apples at 8th day = 46.5g

Difference in loss of mass between unwrapped
and wrapped = $70 - 46.5$
 $= 23.5\text{g}$



[3]

- (iv) Suggest **two** processes by which the apples lost mass.

Respiration, as stored foods get used up. Evaporation, so water loss.

Decomposition, to fruit mass is lost by microbial action.

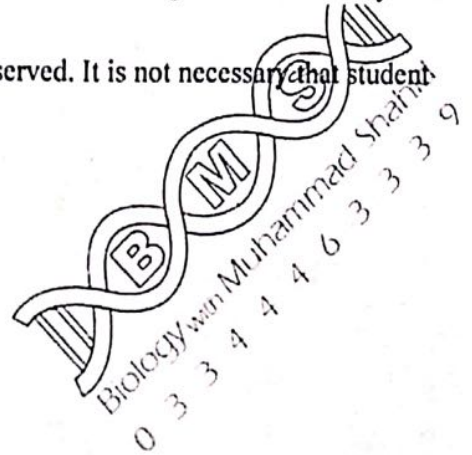
[2]

[Total: 25]

Observations & Conclusions

There are many cases when students are asked to explain the **reasoning** for such visibility or appearance of structures.

Student's ability for **explanation** and **suggestion** are observed. It is not necessary that student will be familiar with entire procedure previously.



Worked Solution

- 1 When shoots are cut from plants, the leaves soon begin to wilt.

Fig. 2.1 shows two similar shoots cut from the same type of plant. Immediately after cutting, the cut end of shoot D was placed in a beaker of water and the cut end of shoot E was placed in an empty beaker.



Shoot D



Shoot E

Fig. 2.1

- (a) Describe **two** differences between shoot D and shoot E as shown in Fig. 2.1.

The leaves of shoot D look healthier, turgid, and upright as
 compared to shoot E which has leaves which are wilted. Condition
 of leaves in shoot E look unhealthy. Moreover, they also look
 shrivelled, and crumbled.

.....
 [2]

The cut ends of both shoots were placed in a beaker containing coloured water and left for ten minutes.

The shoots were removed and dried with a paper towel to remove the excess coloured water. The shoots were cut transversely every 10mm and examined to see whether the coloured water had moved up the shoots.

Fig. 2.2 shows the sections from both stems as they were seen.

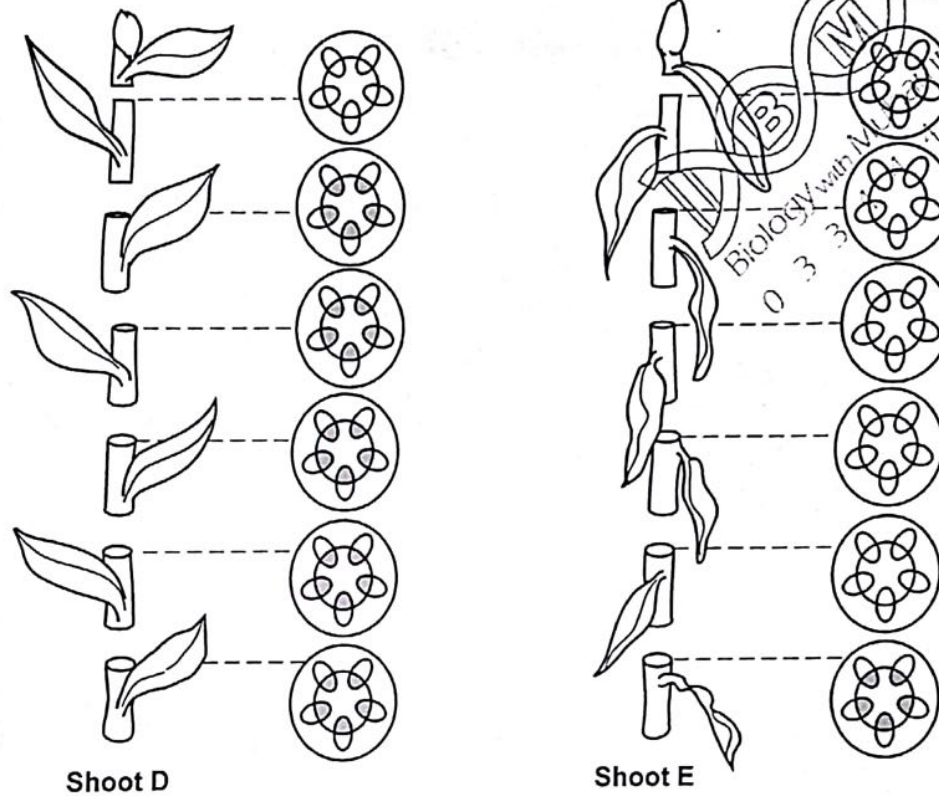


Fig. 2.2

- (b) (i) Use Fig. 2.2 to count the number of sections that show some colour.

Record in Table 2.1.

[2]

- (ii) Use Fig. 2.2 to calculate the distance the coloured water has moved up in each shoot.

Record in Table 2.1.

Table 2.1

shoot D		shoot E	
number of sections with colour	distance coloured water has moved /mm	number of sections with colour	distance coloured water has moved /mm
5	50	1	10

- (iii) Suggest which process caused the coloured water to move up these shoots.

Evaporation inside the leaf spongy mesophyll and transpiration from the leaf surface cause/applied pulling force for water uptake. [1]

- (iv) Suggest why this process took place at a faster rate in one of the shoots.

Shoot E has leaves that are wilted, hence the guard cells would be flaccid. Shoot D has upright leaves, which means that shoot D's leaves would have greater leaf surface area.

[2]

- 2 Some students wanted to find the effect of sugar solution on onions.

They cut slices of onion 2mm thick from a whole onion as shown in Fig. 1.1A. One ring was separated and cut into two equal pieces as shown in Fig. 1.1B.

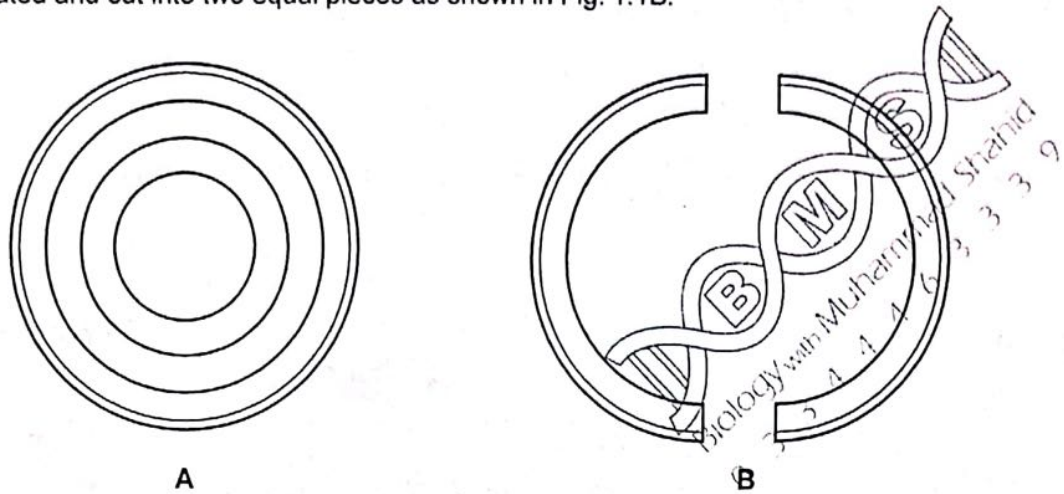


Fig. 1.1

One half of this onion ring was immersed in distilled water in a dish and the other half in a sugar solution in another dish.

The shape of these two pieces at the start was recorded in Table 1.1.

The dishes were left for 30 minutes under the same conditions and then the piece of onion ring in each dish was observed and its shape drawn in Table 1.1.

Table 1.1

	shape of the piece of onion ring	
	in distilled water	in sugar solution
at the start		
after 30 minutes		

- (a) (i) Describe the changes that are visible in the two pieces of onion after 30 minutes.

In water onion ring straightens or opens. In sugar solution onion ring is more curved inwards and curve starts to close up.

[3]

- (ii) Explain what has happened to cause the changes in the two pieces of onion.

Water has moved in or out of onion piece depending on solution it is in. In sugary solution, water diffuses out of onion into sugary solution but in distilled water, water moves into onion from distilled water. Both of these processes are osmosis. Water moves from high concentration to low concentration. As in sugary solution, onion has higher water potential, water leaves onion but in distilled water, onion has a lower water potential so water enters onion. This occurs through partially permeable membrane. Piece in water, more turgid and in sugary solution less turgid. As outer layers water proof, less changed.

[5]

- (b) (i) State one factor that was kept the same in this investigation and explain why it was kept the same.

Same source of onion so same cells and same water potential of cells, so cells have same amount of initial water. Same length of time in solution so same opportunity for movement of water to occur.

[2]

- (ii) Some students decided to find out the effect of using a range of different concentrations of sugar solution on pieces of onion.

Describe two other factors that would need to be controlled.

- 1 Volume of solutions to be same
- 2 Same type of sugar in each solution

- (iii) Explain how you could **measure** the effect of using a range of different concentrations.

By measuring the changes in distance between the two ends using
a ruler, or by measuring changes in mass by electronic balance.

- (c) In one of the sugar concentrations the shape of the onion remained unchanged.

Suggest an explanation for this.

There is no net movement of water and equilibrium has been reached.

The concentration of water of external solution matches that of internal
solution in onion so water potential same inside and out and no
diffusion / osmosis occurs.

3 A student investigated the digestion of protein in mammals.

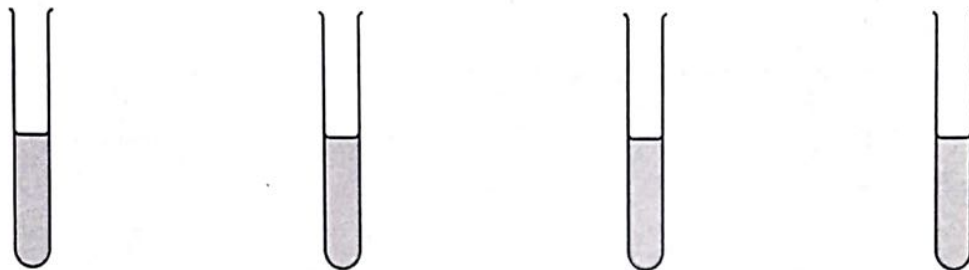
He used:

- a solution of protein that is milky in appearance
- a solution of an enzyme that is found in the stomach of mammals
- a pH solution with a particular pH value
- some distilled water.

He knew that, as the protein was digested, the protein solution would turn from milky to clear.

He set up four test-tubes, **A**, **B**, **C** and **D**, and put 5 cm³ of protein solution into each one. He then placed the four test-tubes in a water bath for 5 minutes.

After 5 minutes, he added other solutions to the 4 test-tubes so that their contents were as shown:



A	B	C	D
5 cm ³ protein solution	5 cm ³ protein solution	5 cm ³ protein solution	5 cm ³ protein solution
5 drops of distilled water	5 drops of pH solution	5 drops of distilled water	5 drops of pH solution
5 cm ³ distilled water	5 cm ³ distilled water	5 cm ³ enzyme solution	5 cm ³ enzyme solution

He returned the 4 test-tubes to the water bath and observed them for the next 5 minutes.

At 3 minutes, the contents of test-tube **D** became clear.

At 5 minutes, the contents of test-tube **C** became clear.

At 5 minutes, the contents of test-tubes **A** and **B** remained milky.

(a) Use this information to complete the table, including the column heading.

time / minutes	observations			
	A	B	C	D
0	milky	milky	milky	milky
1	milky	milky	milky	milky
2	milky	milky	milky	milky
3	milky	milky	milky	milky
4	milky	milky	milky	clear
5	milky	milky	clear	clear

[3]

(b) Explain what the student could conclude about the digestion of protein from these results.

He would conclude the amount of enzyme solution needed to digest protein. Also, that the enzyme digests protein quickly with the pH solution added as well.

[2]

(c) (i) Suggest a suitable temperature for the water in the water bath and explain why that temperature should be used.

A suitable temperature would be 37°C as it is the body temperature of most mammals and where enzyme would function at optimum.

[2]

(ii) Suggest a suitable piece of apparatus:

for measuring the volume of enzyme solution syringe

for adding the pH solution pipette

[2]

(iii) Explain why distilled water was added to test-tubes A, B and C.

To control dilution of pH and enzyme solutions.

[1]

Designing and Planning

How to design and plan an investigation

While planning or designing an investigation recall **CORMS**. Think carefully and design reliable, precise and accurate investigation.

CORMS

Control = +/- range of values

Organism = species/size/age/sex

Replication = more than one reading and average

Measure = units/time delay

Same = temperature/pH/water/humidity

The investigation you design should have a one factor present in one set and absent in the other.

- A control experiment is for comparison and provide a fair test and reliable results. Take an example of control experiment, set two apparatus for photosynthesis. Keep one in light and provide all other factors needed for photosynthesis and other in dark (one factor, light is missing) with other conditions needed for photosynthesis. A factor that changes during the course of time in an investigation is called a variable.
- All biological investigations used some specimen organisms. In control experiment organism used should belong to same species, size, gender, age or biomass etc.
- Experiment should be repeated so that factors of human errors are rectified.
- Take measurement accurately in same units and over a significant period of time.
- Put data in tabular form with specific units etc.
- Calculate the mean of all readings.
- During course of investigation all other factors are to be kept constant except for one that is being investigated.
- Include any hazard and safety warnings or safety equipment should recommended.

Reliability

Reliability is about the likelihood of getting the same results if you did the investigation again and being sure that the results are not just random. Reliability is also called repeatability for this reason.

If you repeat an investigation several times and get the same result, it is said to be reliable.

Reliability of an investigation can be improved by **controlling other variables** well so that they do not affect the results. **Repeating** the experiment until no anomalous values/results are achieved.

Precision

Precise result deviate a little from mean. Precision of an investigation can be improved by using **apparatus that has smaller scale divisions**.

Accuracy

Accuracy is a measure of how close the measured values is to the true value. this accuracy of the result depends upon the skills of the person and measuring apparatus. Accuracy can be improved by:

1. **improving the design** of the investigation
2. using more **precise apparatus**
3. **repeating** the measurements and taking mean

MUHAMMAD SHAHID, O/AS/A-Level & SAT-II
Biology Teacher, SICAS-SLC

Worked Solution

- 1 Design an experiment you could carry out in the laboratory to investigate the effect of pH on the time taken for milk to coagulate using Fromase® enzyme.

I would collect 5 test tubes, one with 2cm³ of sulphuric acid, the other with 2cm³ of citric acid, the third with 2cm³ of toothpaste, the fourth one with 2cm³ of NaOH and last one with 2cm³ water. I would then add 10cm³ of milk to each test tube and 5cm³ of Fromase to all test tubes as well. All 5 test tubes would be kept at a constant temperature of 40°C. I will then measure the time taken for milk to coagulate in each test tube. I can do this experiment multiple times and record a mean value.

[4]

- 2 Cobalt chloride paper is blue when it is dry, but turns pink in the presence of water.

Describe an investigation using cobalt chloride paper that you could carry out to compare the rates of transpiration from the upper and lower surfaces of a leaf.

I would take two equal sized samples of cobalt chloride paper and put them on either side of the leaf, sealing both sides with glass slides using paper clips. This would ensure that no water from our hands or the atmosphere reaches the paper and only water from the leaf reaches it. After this is done, I would measure the time taken for a color change to be observed on the cobalt chloride paper from blue to pink. The faster the color change, the greater the rate of transpiration. Both sides of the leaf will be exposed to same intensity of light and temperature and further more than 1 leaf can be used to add reliability by taking mean of rate. [4]

- 3 Long bones in arms and legs are hollow as shown in Fig. 3.1.

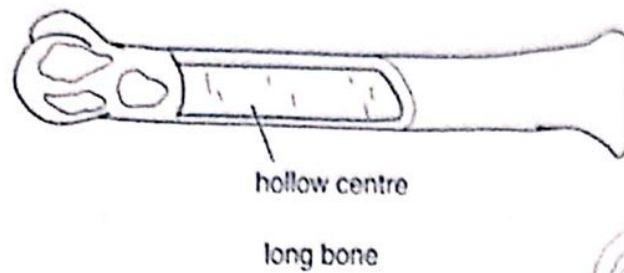


Fig. 3.1

Some students wanted to test their idea that the longest bones were the strongest.

They used a roll of paper to represent a bone and supported it between two stands, as shown in Fig. 3.2. Masses were added to a hook over the 'bone'. More 5g masses were added until the 'bone' began to bend and the total mass that caused this bending was recorded.

The apparatus is shown in Fig. 3.2.

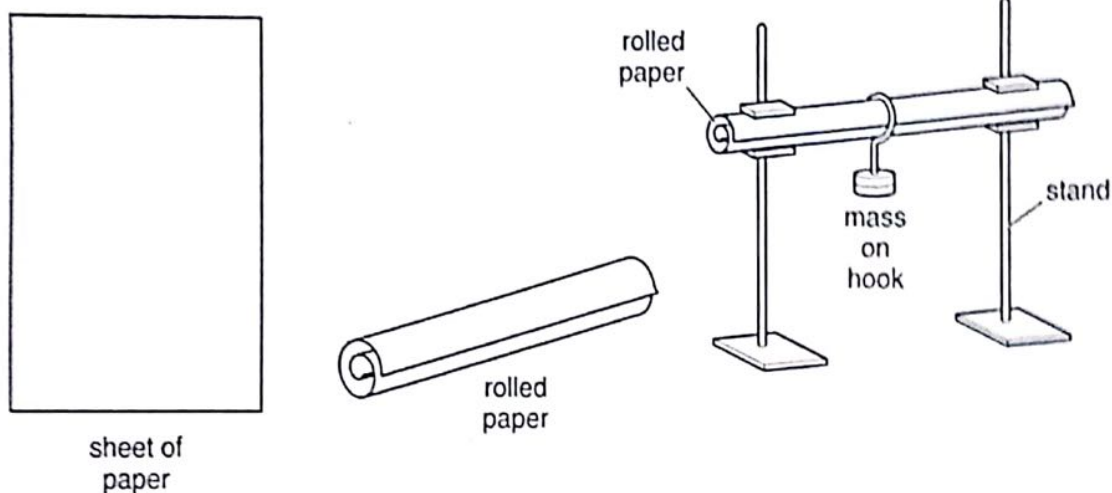


Fig. 3.2

- (a) Describe **two** variables that the students would need to keep constant during this investigation.

1 The diameter of the rolled paper should be kept same.

2 Same mass of hook.

.....[2]

Their results are shown in Table 3.1.

Table 3.1

length of 'bone'/cm	mass that caused the bending/g
10	75
20	65
35	50
40	30

- (b) (i) Describe the trend shown by these results.

As length of cylinder increases, mass needed for bending
decreases. [1]

- (ii) Suggest the conclusion the students reached from their results.

Shorter bones are stronger than longer bones. [1]

- (c) Design an investigation using similar apparatus to find out whether thicker bones are stronger than thin bones.

You should consider the need to obtain reliable results when designing your investigation.

I would set the apparatus similar to shown as the diagram. A sheet of
rolled paper with less folds in between will represent the thin, bone and
rolled paper with more folds in between represent the thick bone. I will
slowly increase number of 5g weights on both the sheets of paper. Also, I
will set the supports of paper at same distance apart. Afterwards, I
will keep adding weights until it bends. The paper that bended at lesser
weight would be weaker.

[4]

- 4 Some people rinse their mouths after eating with a liquid called mouthwash. Manufacturers of mouthwash claim that it helps to reduce dental decay.

Describe how you would investigate whether using mouthwash after eating affects the pH of plaque in a group of 10 students.

To fairly investigate the effect of using mouthwash I can make all ten of the students, eat the same type and amount of food. After they have eaten it, I will measure the pH of the plaques of the ten students. After that, I will make two groups of 5, 5 students, one group will rinse their mouth with mouthwash, other group will rinse with water. Same volumes of mouthwash and water will be used and afterwards I will measure the pH of tooth plaque of all students again. I will compare the pH value of the group which used the mouthwash with the group that used water and see which groups pH is closer to 7.

[5]

Suggestion & Improvement

Recommending suggestions and making improvements in experimentation

While suggesting an improvement in the described or shown experimental details, first of all suggest **repeating** experimentation at least thrice and take a mean and further by keeping in mind all the variable parameters write about keeping them **constant** in all the repeated procedures. The suggestion of keeping parameters constant varies from situation to situation in each experimentation.

Extension of these sort of experiments could be:

1. **recommendation** for improvement in experimental procedure
2. increasing the **reliability, precision and accuracy** of given method
3. Using data obtained in experimentation (given in table) to make a **graph**

In few cases experimental details are bit unfamiliar to student but in extension of process given students may be asked to recommend sort of experimentation for any **other variable** like pH effect on process and to enhance the **reliability** of procedure etc.

Remember !

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If you repeat an investigation several times and get the same result, it is said to be reliable.

Reliability of an investigation can be improved by **controlling other variables** well so that they do not affect the results. **Repeating** the experiment until no anomalous values/results are achieved.

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Precise result deviate a little from mean. Precision of an investigation can be improved by using **apparatus that has smaller scale divisions**.

Accuracy

Accuracy is a measure of how close the measured values is to the true value. this accuracy of the result depends upon the skills of the person and measuring apparatus. Accuracy can be improved by:

1. **improving the design** of the investigation
2. using more **precise apparatus**
3. **repeating** the measurements and taking mean

Worked Solution

- 1 Some students investigated the effect of adding a known volume of an enzyme to some crushed apricot fruit. The mixture was stirred to mix the enzyme thoroughly with the fruit. The mixture was filtered. The volume of juice collected is shown in Fig. 1.1A.

To a second sample of fruit they added the same volume of water instead of the enzyme. This mixture was filtered. The volume of juice collected is shown in Fig. 1.1B.

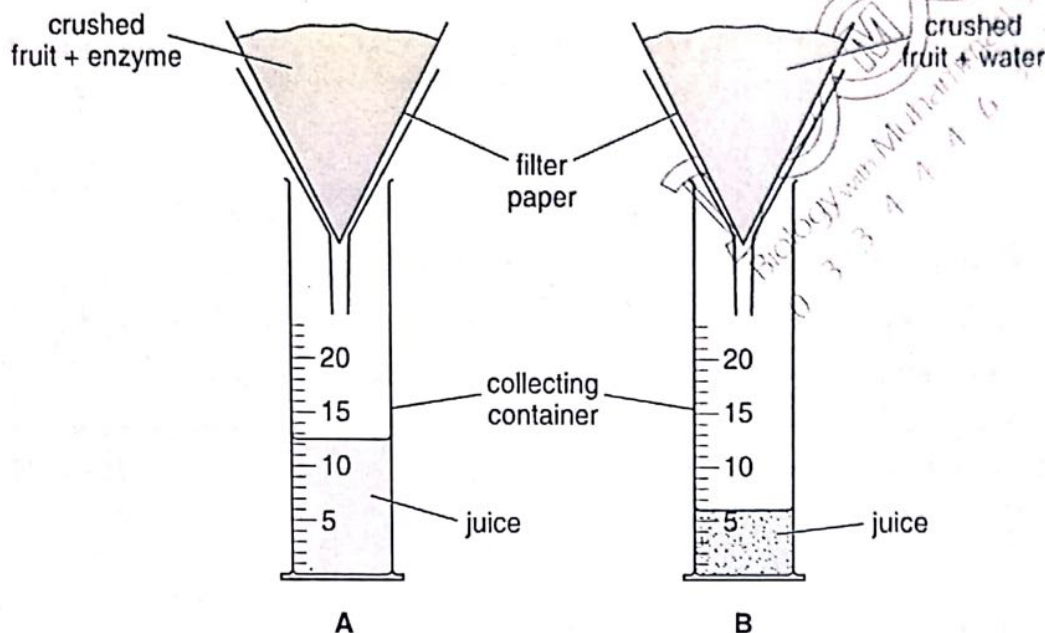


Fig. 1.1

- (a) (i) In Table 1.1, record the volumes of juice collected as shown in Fig. 1.1.

Table 1.1

sample of juice	volume / cm ³	appearance
A	12.5	clear
B	6	cloudy

[2]

- (ii) The enzyme is used in the production of fruit juice on a large scale. Using the information in Table 1.1, suggest **two** reasons why the enzyme is used.

The enzyme is used as it gives more juice collected in measuring
cylinder and as it is clear unlike the method used in B.

.....[1]

- (iii) Suggest why water was added to the crushed fruit in B.

For comparison with the amount collected in A.

- (iv) State **two** variables that need to be kept constant in this investigation.

1 Same mass of crushed fruit.

2 Time taken for filtration should be same.

- (v) Suggest **two** ways in which the investigation could be improved to increase the reliability of the results.

1 Average/mean can be taken to obtain accurate results after repeating experiment number of time.

2 Crushed fruits volume should be measured and kept constant for both experiments.

- 2 Some students carried out an investigation to find the effect of the shape of an animal's body on heat loss from the body. Heat loss was measured as a decrease in temperature in $^{\circ}\text{C}$.

They used two plastic containers, A and B, to represent two differently shaped bodies of an equal volume.

The containers used are shown in Fig. 1.1.

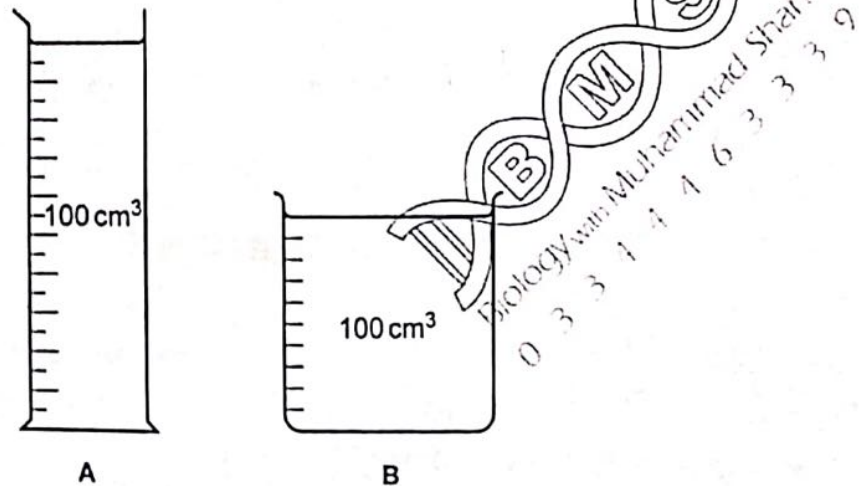


Fig. 1.1

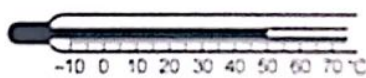
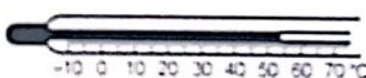
The two containers, A and B, were each filled with 100 cm^3 of hot water. A thermometer was used to measure the temperature of the hot water in each container immediately. These temperatures were recorded at 0 minutes.

Temperatures were then recorded for each container every two minutes, for a total of eight minutes.

Table 1.1 is an incomplete results table from this investigation.

(a) Complete Table 1.1.

Table 1.1

Time elapsed/min.	temperature/ $^{\circ}\text{C}$	
	A	B
0	65	65
2	55	58
4	 50	 54
6	46	50
8	40	47

- (b) Calculate and record the overall decrease in temperature of the water for each container and record these two values below.

Show your working.

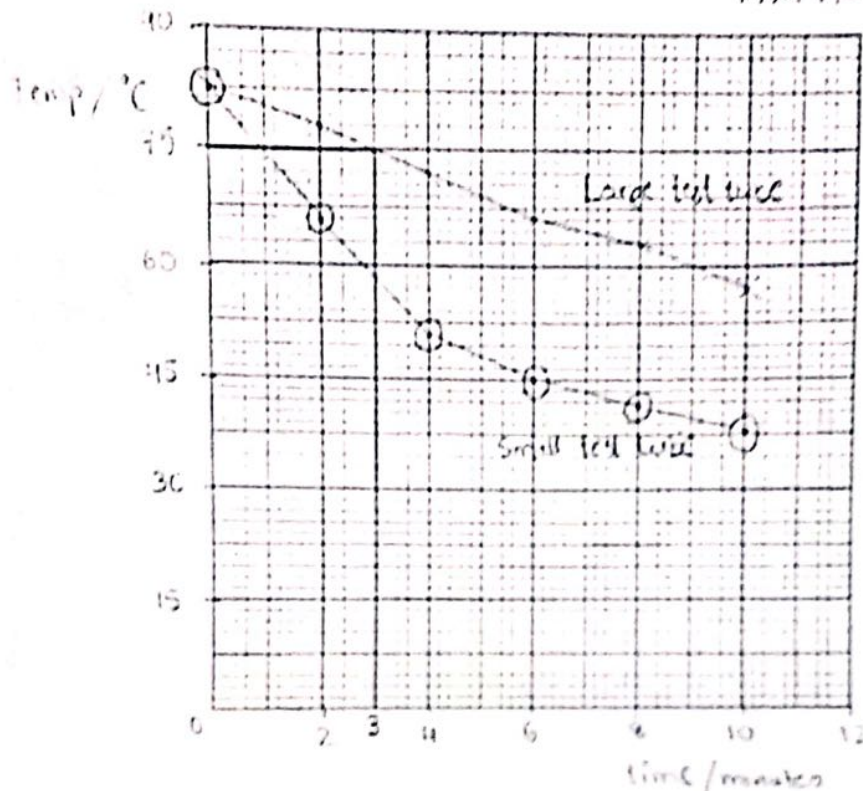
$$A = 65.40 \\ = 25$$

$$B = 65.47 \\ = 18$$

A 25 °C

B 18 °C

- (c) (i) Construct a graph to show the decrease in temperature of the water with time, in containers A and B, using the results in Table 1.1. Use the same axes for both sets of data.



- (ii) Describe these results.

There is a drop in temperature of both containers. In A, there is more decrease in temperature compared to B. In A and B temperature drop is most within the first two minutes.

[2]

- (iii) The shape of a container **does** affect the heat loss from the container.

Suggest an explanation for this.

A container with large surface area loses more heat through conduction after which water vapour condenses on the surface and then evaporates with the heat energy.

(d) State three factors that were kept constant in this investigation.

- 1 Volume of water
- 2 Time across which the temperature was measured
- 3 Material of the container

(e) Suggest and explain two possible improvements to the method used in this investigation. [3]

improvement 1 Use of automation. A data logger and a digital thermometer.

explanation This removes human error and increases the precision of the results obtained and record them.

improvement 2 Measuring time in shorter intervals.

explanation This would show a clear trend and make a clear graph.

[4]

- 3 (a) Dehydrogenase is an enzyme found in cells such as yeast.
Methylene blue is an indicator that can be used to show the activity of dehydrogenase.

In the presence of active dehydrogenase, methylene blue changes colour from blue to colourless.

A student carried out an experiment to investigate the effect of temperature on the activity of dehydrogenase, using yeast suspension (yeast mixed with water).

They carefully measured 5cm^3 of yeast suspension and placed this in a test-tube labelled A.

The student also measured 5cm^3 of yeast suspension which had been boiled and then cooled, and placed this in a test-tube labelled B.

Both test-tubes were placed in a beaker of water kept at 25°C . After 5 minutes, the student added 1cm^3 of methylene blue solution to each test-tube and mixed the contents.

Then every minute for 10 minutes they observed the contents of the two test-tubes and recorded their observations.

The student then repeated this experiment at a temperature of 35°C .

Their observations are shown in Table 1.1.

Table 1.1

temperature $^\circ\text{C}$	test-tube	time after adding methylene blue solution/min									
		1	2	3	4	5	6	7	8	9	10
25	A	✓	✓	✓	✓	✓	✓	✓	–	–	–
	B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
35	A	✓	✓	✓	✓	–	–	–	–	–	–
	B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

key

- ✓ indicates the presence of a blue colour
– indicates the absence of a blue colour

- (i) Explain how you would be able to check that the temperature of the water in the beaker was at 25°C.

I would use a thermometer.

[1]

- (ii) Describe how you would adjust the temperature if it became higher or lower than 25°C.

I would use a flame to increase the temperature if it fell from a bunsen burner, or add cold water if it rose.

[1]

- (iii) Explain why the test-tubes were left in the beaker of water for 5 minutes before adding methylene blue solution.

To allow contents of the test tube to adjust to the temperature of the water.

[1]

- (iv) Using the information in Table 1.1, describe the student's observations.

In tube A, at 25°C, blue color disappears after 7 minutes and becomes colorless. In solution A at 35°C, blue color turns colorless after 4 minutes. In tube B, the blue colour remains unchanged at 25°C or 35°C.

[3]

- (v) Suggest an explanation for their observations.

There is no change in tube B as enzymes globular nature has become denatured because of extreme heat and the yeast no longer reacts with the solution. In tube A, enzymes are working and become more efficient at 35°C as it may be or may be close to optimum temperature.

[3]

- (vi) Suggest one way in which this experiment could be improved to increase the reliability of the results.

Repeat the temperature and take average/mean of times.

[1]

- 4 Some students carried out an investigation into the movement of food molecules from the intestines using a length of Visking tubing to represent a part of the digestive system. Visking tubing is made of a flexible transparent material.

- One end of the length of tubing was securely tied to close it as shown in Fig. 1.1
- This tubing was filled with a solution containing both the reducing sugar glucose and starch.
- The outside of the tubing was rinsed with water.
- The tubing was placed into a large test-tube filled with clean water and held closed and in position, by a clip.

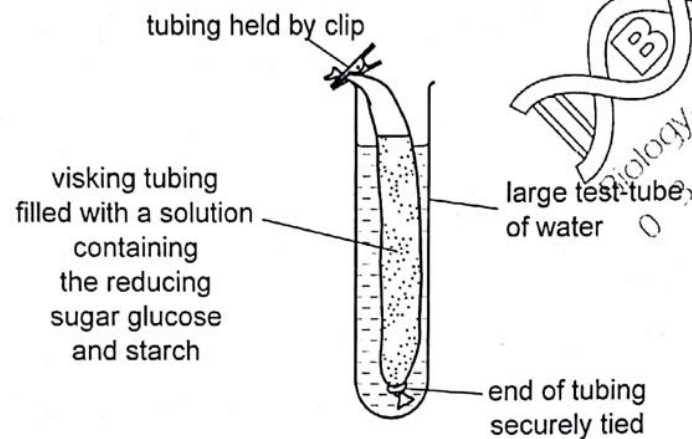


Fig. 1.1

Samples of the water from the large test-tube were tested for the presence of reducing sugar and starch at different time intervals.

- (a) Describe how you could safely test for the presence of

- (i) reducing sugar

I will add equal amount of benedicts solution to the sample and heat it to 90°C for 5 min. in water bath while wearing goggles for safety. If color turns from blue to green, yellow, orange or brick red, the presence of reducing sugars can be confirmed.

[4]

- (ii) starch.

Add few drops of iodine solution to the sample, if it turns from yellow/brown to blue/black, then starch is present.

[2]

- (b) Explain why the outside of the tubing was rinsed before it was put into the large test-tube of water.

To ensure purification of the test tube without any starch or sugar

The results from the samples of water tested are shown in Table 1.1.

Table 1.1

sampling time / min	reducing sugar test	starch test
0	negative	negative
2	negative	negative
20	positive	negative

- (c) Suggest and explain what had happened during the 20 minutes to produce these results.

Diffusion has taken place as reducing sugars or glucose moved
from an area of higher concentration to an area of lower
concentration. Respectively, from the visking tube to the test tube.
Glucose can pass out due to its relatively small molecular size
than starch. As due to small molecule size, no energy is needed for
its movement as it goes down the concentration gradient.

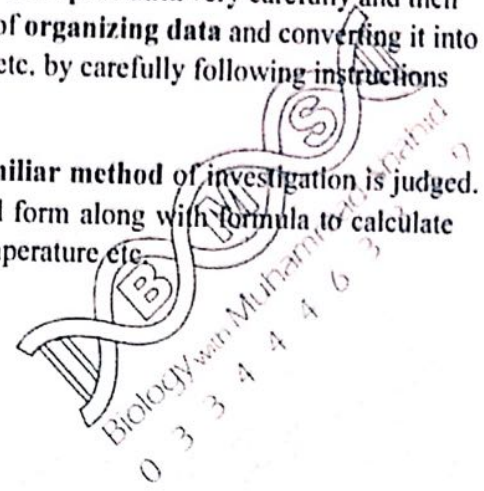
.....
.....
.....
..... [5]

- (d) Suggest, giving your reasons, which part of the digestive system might be represented by the Visking tubing in the water in this investigation.

It represents small intestine as absorption of reducing sugars is
done into water and in blood, respective to the small intestine.

.....
..... [3]

In some cases the ability of student to cope with **unfamiliar method** of investigation is judged. The base procedure may already be given in sequenced form along with formula to calculate various parameter like calculating energy value and temperature etc.



Worked Solution

1 Some students were provided with a solution C, prepared from seeds soaked in water, ground up and filtered.

- They were provided with damp starch paper in a Petri dish.
- They added drops of dilute iodine solution so that it was evenly stained.
- Three small discs of filter paper were cut and soaked in solution C.
- These discs were carefully placed onto the stained starch paper in the Petri dish.
- The lid was replaced, as shown in Fig. 2.1.
- The time was noted.
- They looked at the dish every minute for 6 minutes. Around the filter paper discs on the starch paper were zones of yellow which increased in diameter with time.

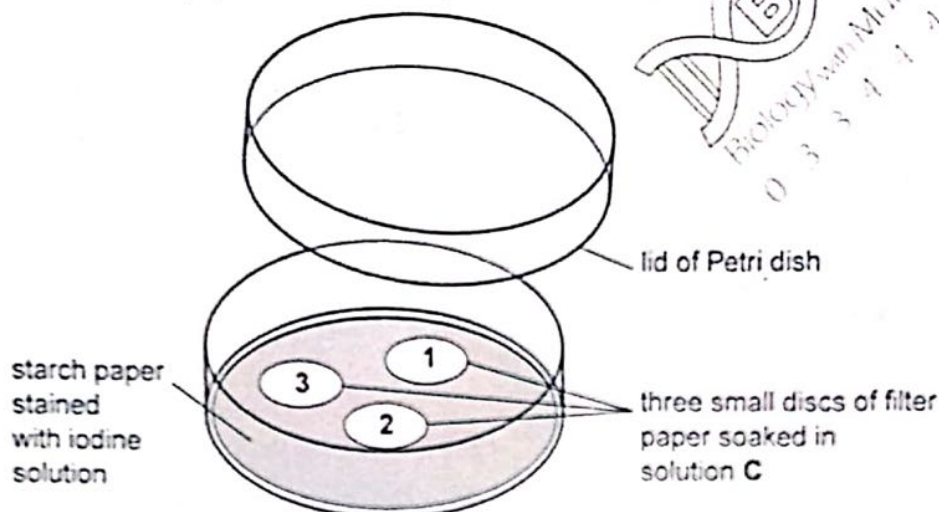


Fig. 2.1

Fig. 2.2 shows the diameter of these zones after six minutes.

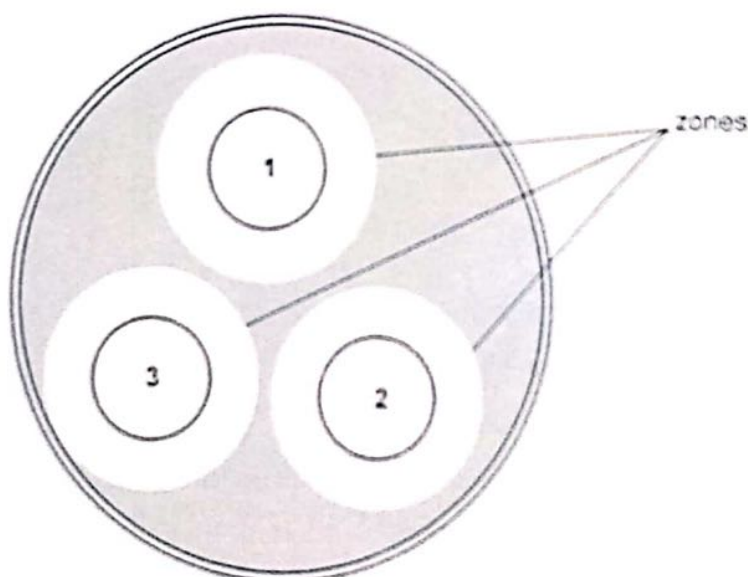


Fig. 2.2

- (a) Measure the diameter of each of the zones shown in Fig. 2.2 and record your measurements in Table 2.1.

Table 2.1

time/min	diameter of yellow zone/mm		
	1	2	3
0	15	15	15
1	17	16	16
2	19	18	19
3	23	21	22
4	25	24	26
5	27	28	28
6	30	28	28

[2]

- (b) (i) Describe a positive test for the presence of starch.

The iodine solution turns blue/black when starch is present.

[1]

- (ii) Suggest and explain what has happened to the starch around the discs.

It can be inferred that the solution C contained an enzyme that
break down the starch on the starch paper to reducing sugars.

This causes the area around the dishes to turn yellowish as
the solution C diffuses over time deeper onto the paper.

[3]

- (iii) Explain why seeds need the substance that has caused this to happen.

Seeds can't perform photosynthesis as they don't have access to light, and have no chloroplasts, have they gain their energy from respiration, and this substance is vital in aerobic respiration. It also breaks down stored starch reserves to get energy for growth.

[3]

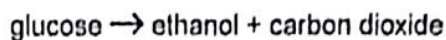
- (c) Describe how this method could be used to compare the seeds from two different types of plant.

Firstly, one would prepare solutions from ground seeds of both different plants. Volume of water, and mass of seeds to be kept constant. Disks made up of soaked filter paper to be placed on the stained paper, and they should be left for some time, and then both diameters should be compared.

[3]

- 2 Some students investigated the effect of two solutions, ethanol and sucrose, on the respiration of yeast.

Yeast, a type of fungus, can respire anaerobically. This is called fermentation and results in the formation of ethanol (alcohol) and carbon dioxide.



Three beakers, labelled A, B and C, were used. Each beaker contained 10cm^3 of active yeast mixture (a mixture of yeast in glucose solution). A different solution was then added to each beaker, as shown in Fig. 1.1.

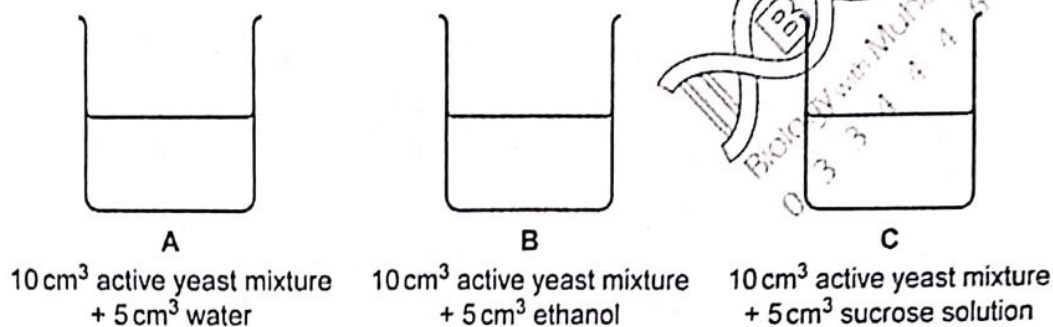


Fig. 1.1

A syringe labelled A was filled with 10cm^3 of mixture from beaker A.

A syringe labelled B was filled with 10cm^3 of mixture from beaker B.

A syringe labelled C was filled with 10cm^3 of mixture from beaker C.

A narrow glass tube, with an ink mark close to one end, was attached to each syringe (using a small piece of flexible tubing) as shown in Fig. 1.2.

The plunger of each syringe, A, B, and C, was pressed to bring the meniscus of the mixture to the level of the ink mark on the narrow tube, as shown in Fig. 1.2.

The time was noted. This was the start time, 0 minutes.

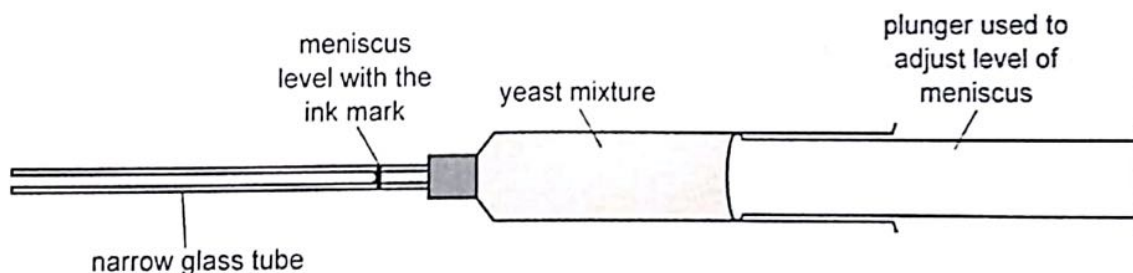


Fig. 1.2

As the actively respiring yeast released carbon dioxide, the volume of the mixture increased and the meniscus moved along the narrow glass tube to the left.

After 10 minutes, 15 minutes and 20 minutes, the distance moved by the meniscus was measured, in mm, and recorded for each tube.

Table 1.1 was drawn to record the results of the investigation.

Table 1.1

Time (mins)	distance meniscus moved/mm		
	A	B	C
0	0	0	0
10	8	1	10
15	10	1	15
20	12	2	22

(a) Complete the headings of Table 1.1.

[2]

The following results were recorded by the students.

In the tube attached to syringe **A**, the meniscus had moved 8mm after 10 minutes, by a further 2mm after 15 minutes, and a further 2mm after 20 minutes.

In the tube attached to syringe **B**, the meniscus had moved 1mm after 10 minutes, did not move any further between 10 and 15 minutes, and then moved a further 1mm after 20 minutes.

In the tube attached to syringe **C**, the meniscus had moved 10mm after 10 minutes, moved to 15mm after 15 minutes and to 22mm after 20 minutes.

(b) Complete Table 1.1 using this information.

[3]

(c) (i) Describe the effect of ethanol on the movement of the meniscus in tube **B** and suggest an explanation for this effect.

description Little to no movement i.e very slow movement of meniscus.

explanation Ethanol kills the yeast or else no respiration occur as a result of which very animal CO₂ is produced.

[2]

(ii) Describe the effect of sucrose solution on the movement of the meniscus in tube **C** and suggest an explanation for this effect.

description Movement increases i.e faster movement of meniscus.

explanation More sugar means more glucose for respiration thus more CO₂ produced.

[2]

- (iii) Explain why syringe A was included in this investigation.

It was the control set up for comparison of effect with that of adding ethanol and sugar.

- (d) Name two variables that were kept constant during this investigation.

1 Volume of active yeast.

2 Diameter of tube or the total volume used.

Carbon dioxide is released during anaerobic respiration.

- (e) Describe a test for carbon dioxide.

When a tube containing carbon dioxide is attached, limewater turns milky if CO_2 is present.